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Analysis of a Gravity Traverse South of Portland, Oregon

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The state gravity maps of Oregon and Washington show a gravity high centered south of Portland, Oregon and a gravity low in the Tualatin Valley to the west disrupting the regional gravity gradient which is controlled by crustal thickening. Detailed gravity surveys done in the Portland area are consistent with the state gravity maps but show considerably more detail. Quantitative interpretation of this data has provided new information on the subsurface structure in this area; recent work has yielded corroborative evidence for a

fault zone bounding the east side of the Portland Hills, and has indicated the presence of faults under the Portland Basin to the east which were previously unknown.

In order to extend this work and examine the structural features to the south of the Portland area a detailed gravity survey was conducted along a line perpendicular to the Portland Hills trend between Oak Grove and Milwaukie. This line crosses the northern portion of the circular gravity high present in the state Bouguer gravity map, and the projected trend of the Portland Hills Fault zone allowing a more detailed examination of these features in this area. An anomalous gravity high of approximately 10 milligals and 20 kilometers width was observed centered over the Portland Hills. Wavelengths associated with this anomaly require that it be produced by a near-surface mass. Data reduction and modeling of the free air and Bouguer anomalies were done using computer programs from Oregon State University adapted to the Portland State University computer system. Modeling indicates a vertical fault with about 300 meters vertical displacement dropping the Miocene Columbia River Basalt down to the east and another smaller fault further to the east in the Portland Basin forming a graben structure. This model is consistent with the projected Portland Hills Fault zone. Several other lines of evidence, including physiography, field and structural mapping, geochemical stratigraphic correlation, and microseismic monitoring, as well as gravity indicate that the predominant motion on this fault is right-lateral strike-slip with as much as 20 kilometers movement since late Eocene time.

In order to best fit the gravity anomaly a large high density intrusion was required in addition to the faulting. Using a density of 3.0 gm/cm^3 for this intrusion it was modeled as being one kilometer thick and 20 kilometers wide, and located directly beneath the Columbia River Basalt. This intrusion is believed to have been a source for the Plio-Pleistocene basaltic Boring volcanic eruptions which have occurred in the area. If this hypothesis is correct then this intrusion could be significantly larger to the south where no detailed work has yet been done, but where the state Bouguer gravity map shows a more extensive gravity high, and geologic evidence indicates larger scale Boring volcanic activity. Other significant results of gravity modeling include the thinning and pinchout to the east of the Eocene-Oligocene sediments, and the broad synclinal shape of both the Portland Basin and the Tualatin Valley. Further gravity work to study these features in adjacent areas is indicated as this method has been shown to be extremely productive.

ANALYSIS OF A GRAVITY TRAVERSE SOUTH OF PORTLAND, OREGON

by

TERRY DEAN JONES

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INTRODUCTION

Purpose and Scope

The geologic setting of the Portland area makes it highly conducive for gravity studies. The near surface geology may be generally characterized by extensive Tertiary volcanic units overlain by localized Pliocene and Quaternary sedimentary formations. Locally Plio-Pleistocene Boring lavas form topographic highs. Eocene-Oligocene marine sedimentary rocks, present in great thicknesses in the Coast Range to the west, thin to the east and are either very thin or absent in the Portland area (Newton, 1969; figure 1) The Miocene Columbia River Basalt flows are present through essentially the entire area and thus form an excellent marker bed. The contact of the Columbia River Basalts with the overlying sediments is marked by a large density contrast.

The Portland Basin and the Tualatin Valley are large alluvial filled synclines in the Columbia River Basalt with the Portland Hills forming an anticline between them (figure 1). However the structure of the volcanic units, in particular the Columbia River Basalt, is largely obscured by the overlying sediments. Outcrops of basalt are few and for the most part highly weathered. The geologic map of the Portland area (Trimble, 1963; figure 2) shows the major features pertinent to this thesis. Brief lithologic descriptions of important units are included in Appendix I.

TUALATIN BASIN-NORTHERN WILLAMETTE VALLEY SUBSURFACE SECTION

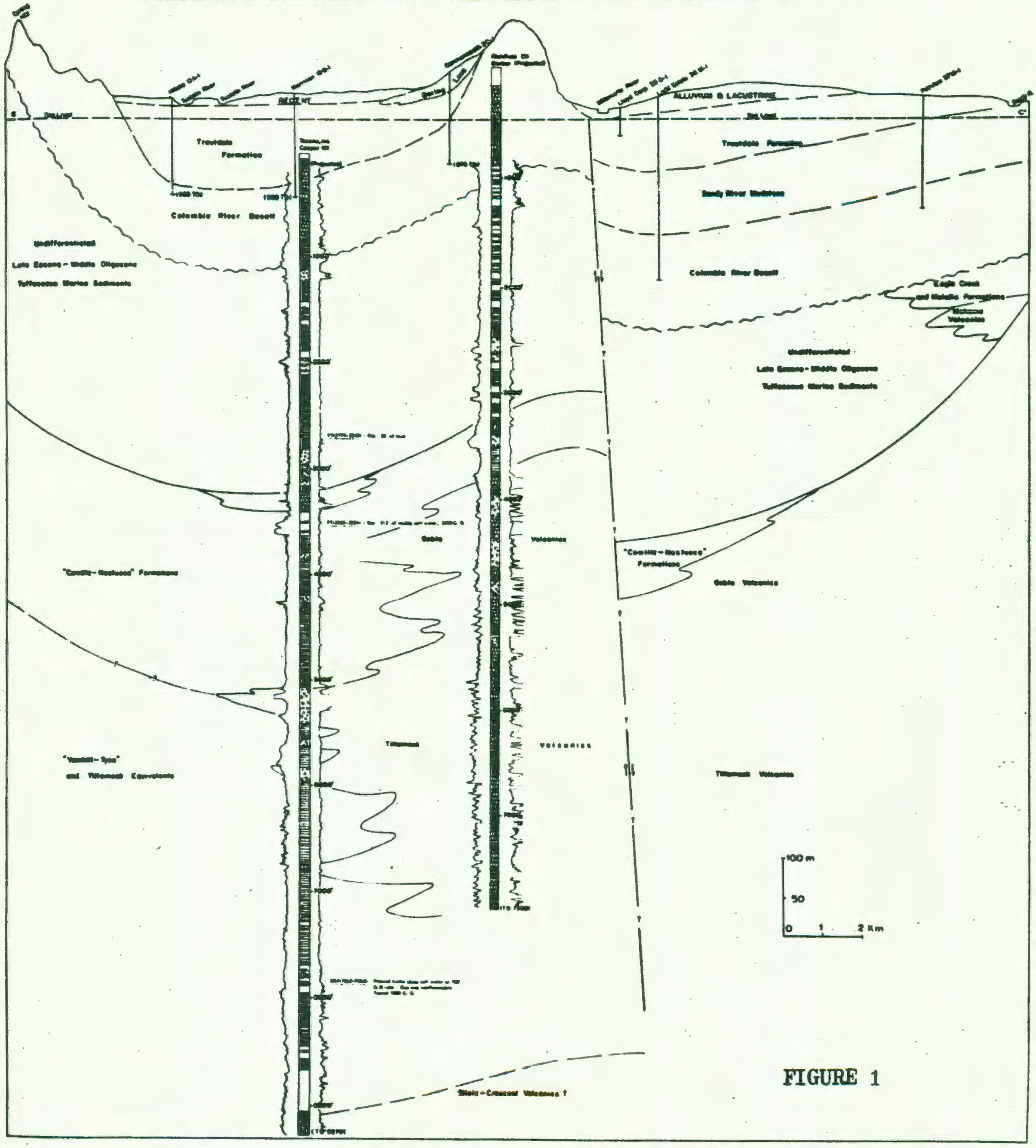
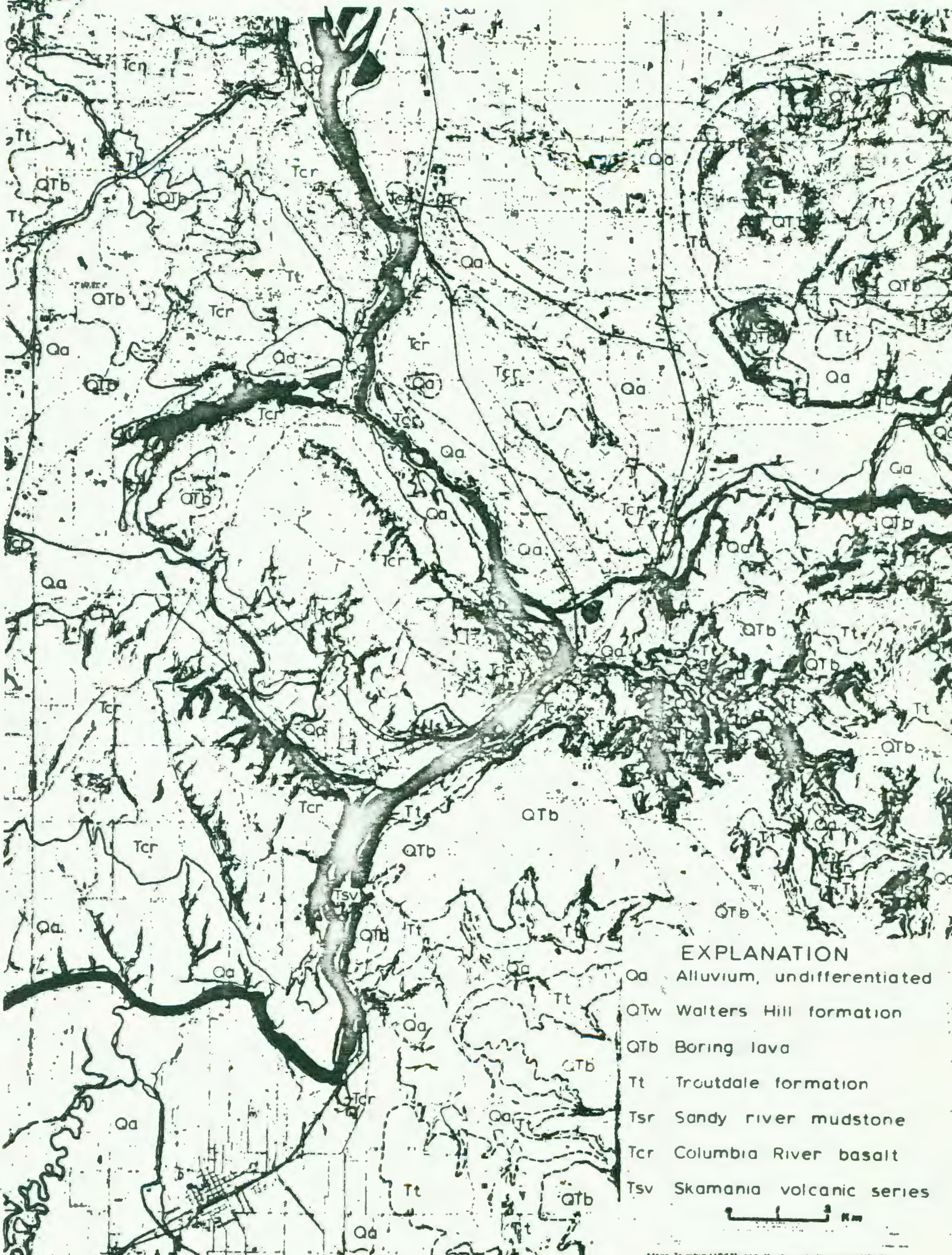


FIGURE 1

From Newton, 1969

FIGURE 2 GEOLOGIC MAP OF THE SOUTH PORTLAND AREA



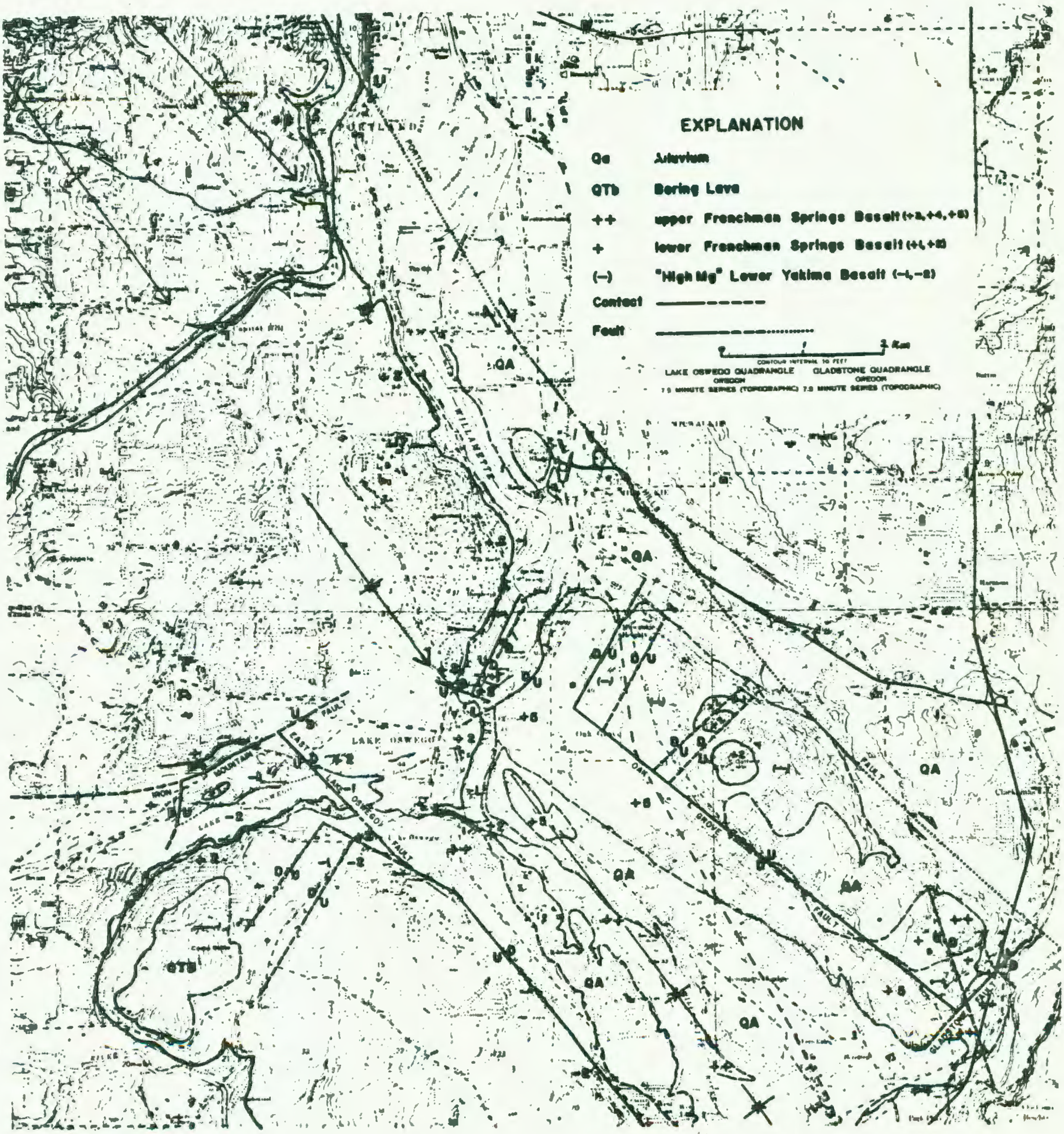
An interpretive cross section based on well logs in the Portland area is shown in figure 1 (Newton, 1969). While the Columbia River Basalt is 350 meters below sea level in the Portland Basin, it outcrops at elevations of 300 meters in the Portland Hills five kilometers to the west. On this basis, as well as the strong northwest trending lineation along the east side of the Portland Hills, it has been suggested that there may be a fault (the Portland Hills Fault) down dropping the Columbia River Basalt to the east of the Portland Hills (Balsillie and Benson, 1971). This possible fault is interpreted in figure 1 as a normal fault.

Previous studies in the Portland area have concentrated on field mapping. More recently geochemistry and geophysics have been used with considerable success. In this study the large density contrast between the volcanic units, particularly the Columbia River Basalts, and the overlying sediments is utilized by running a detailed gravity survey perpendicular to and across the Portland Hills and the Portland Basin. Gravity surveys conducted recently (Beeson et al., 1975; Johnson, 1975; Donovan, 1976; Johnson and Jones, 1976, Jones et al., 1977) have been helpful in defining the subsurface structure which is not apparent from surface mapping. Previous gravity lines have concentrated primarily on the Portland Hills lineament and the Portland Basin in the Portland area. This study is based on the first detailed survey south of Portland.

The South Portland Structure Map shown in figure 3 (Beeson et al., 1975) is based on field mapping, and geochemical and petrographic stratigraphic correlation. Better exposures of the Columbia River Basalts in this area have allowed individual flows to be mapped in

FIGURE 3

SOUTH PORTLAND AREA STRUCTURE MAP



detail, and the shallow structure to be worked out. This map provides good near-surface control for gravity modeling. One of the original purposes of this study was to gain additional evidence for the faults shown in figure 3, particularly the Oak Grove Fault and Lake Oswego Fault. Beeson et al. (1975) interpret these features as a graben on the crest of an anticline. The Oak Grove line crosses perpendicular to this feature as well as to the proposed Portland Hills Fault zone.

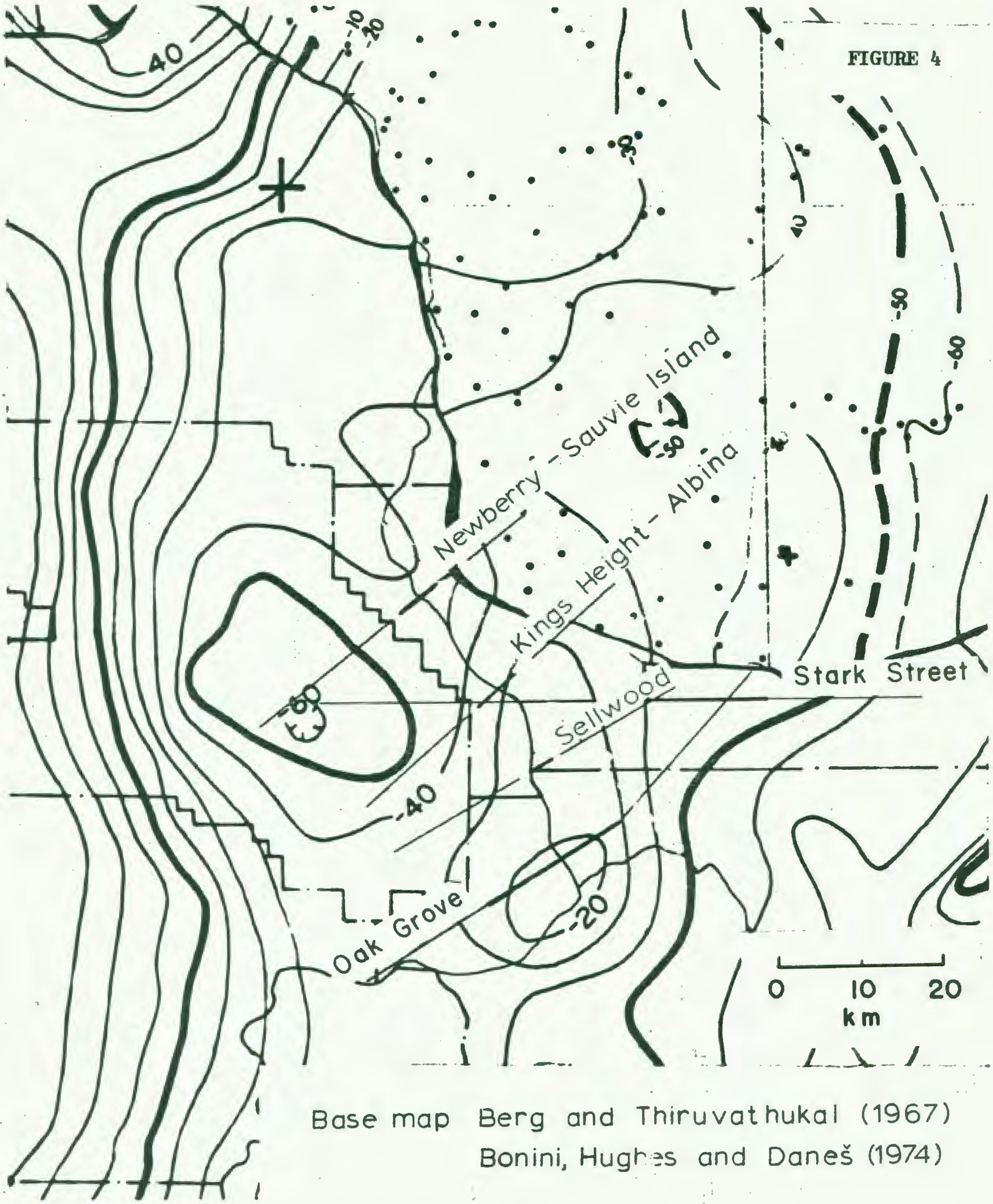
This area is also of interest because it crosses the northern portion of the gravity high shown on the state Bouguer gravity map (Berg and Thiruvathukal, 1967), the northwest portion of which is shown in figure 4. The Oak Grove line allows a more detailed examination of this gravity anomaly to determine its structural significance. Models of parallel gravity lines to the north (Beeson et al., 1975; Johnson, 1975; Donovan, 1976; Johnson and Jones, 1976; Jones et al., 1977) have indicated the presence of the Portland Hills Fault zone, and a shallow intrusive body, as seen in figure 5. Modeling of the Oak Grove line shows the extent of these features to the south.

Location

The location of the Oak Grove gravity line is shown in figures 3 and 4. The detailed section of the line with stations located an average of about 100 meters apart is 11 kilometers long and trends N 50°E. It crosses the Willamette River between Oak Grove and Jennings Lodge and runs from 82nd Avenue on the northeast to the Tualatin River on the southwest. The line is extended in less detail

Bouguer Gravity of Greater Portland Area

FIGURE 4



Base map Berg and Thiruvathukal (1967)
Bonini, Hughes and Daneš (1974)

SELLWOOD GRAVITY MODEL

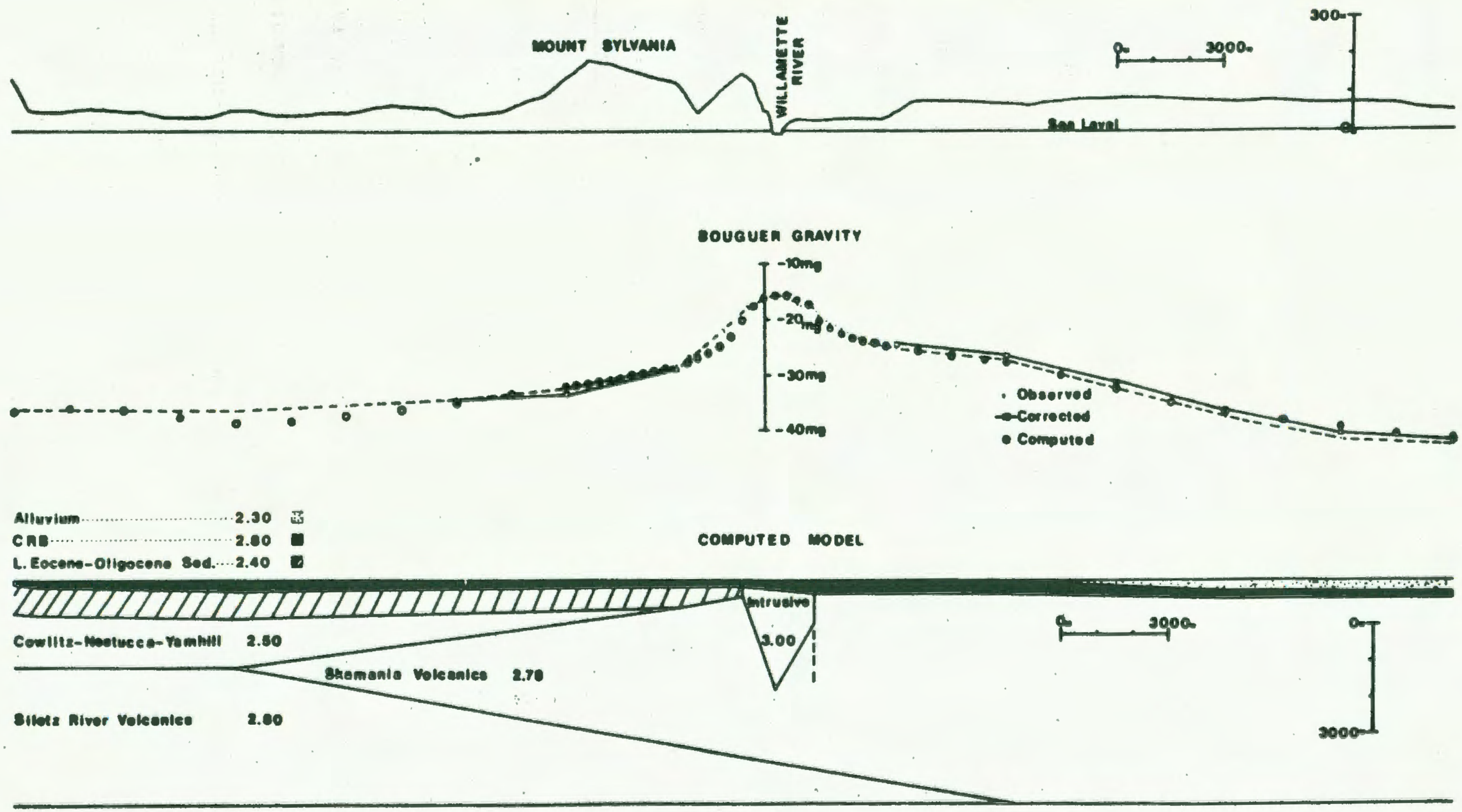


FIGURE 5

to the northeast and southwest for about 10 kilometers with stations located one kilometer apart in order to provide control for the regional structure. Figure 4 shows the entire line in relation to the regional Bouguer gravity anomaly.

Previous Work

Several geologic investigations of a reconaissance nature have been carried out in the Portland area. Diller (1915) studied the area and was the first to believe there was a fault along the east side of the Portland Hills on the basis of the strong northwest trending lineation. The most comprehensive geologic map was made by Trimble (1963), a portion of which is shown in figure 2. Although geologic mapping has been conducted in detail, it has failed to produce any direct evidence for faulting and very little data on the bedrock structure, due to the extensive alluvial cover and advanced weathering. Trimble (1963) interpreted the Portland Hills as a simple anticline in the absence of any subsurface information, but Balsillie and Benson (1971) suggested a fault along the east side of the Portland Hills on the basis of structural, geomorphic, and seismic evidence.

Geophysical research relating to this area includes earthquake first motion studies, gravity, and magnetics. Heinrichs and Pietrafesa (1968) investigated the Portland earthquake of January 27, 1968. Source mechanism solutions for this earthquake indicate either right-lateral displacement along a northwest trending strike-slip fault, or left-lateral movement along a northeast trending strike-slip fault. Normal or reverse faulting resulting in vertical offset was not consistant with the observed data, although a small component of vertical displacement may have accompanied strike-slip motion. Couch et al. (1968) studied the Portland earthquake of May 13, 1968 and reached similar conclusions upon examining focal mechanism solutions. Dehlinger et al. (1963) examined the November 5, 1962 earthquake in Portland and also concluded that source mechanism solutions indicate either right-lateral faulting along a northwest trending strike-slip fault or left-lateral faulting along a northeast trending strike-slip fault. Predominant vertical motion along a normal or reverse fault was again inconsistent with the data. On this basis they suggested that the active fault was probably aligned with the northwest lineation bounding the east side of the Portland Hills. This fits available epicenter locations although the epicenters are not known to a sufficient degree of accuracy to serve as difinitive proof.

Couch and Lowell (1971) reviewed earthquakes and seismic energy released in Oregon. Their work showed a concentration of earthquakes in the Portland area. While this may be to some extent dependent on the population distribution, it does indicate that there is some current tectonic activity in this area. Focal depths reported were generally from 5 to 25 kilometers indicating crustal shocks. Focal mechanism solutions were shown to characterize a regional stress field where the minimum compressive stress (relative tension) is aligned east-west and the maximum compressive stress is north-south which is consistant with right-lateral motion along a northwest trending strike-slip fault. Seismic energy released during the 100 year period from 1870 through 1970 indicates a seismic level equivalent to one magnitude 5.2 earthquake every 10 years, with a maximum intensity of VII. Microseismic monitoring has recently been initiated in the

Portland area by Johnson (1976). Sufficient microseismic activity has been recorded to show that the results are consistant with those for previous larger earthquakes.

Regional gravity and magnetic surveys of western Oregon have been compiled by Bromerly and Snavely (1964). Interpretation of the anomalies has provided information on the structure of the Coast Range, but the data does not extend far enough into the Willamette Valley to yield any useful information on the Portland area. Zietz ét al. (1971) discuss an areomagnetic strip which passes just north of the Portland area. This study was of a regional nature but the magnetic anomaly map shows several prominent northwest trending lineations in southwest Washington, approximately parallel to trends observed in other studies (Balsillie and Benson, 1971; Schmela, 1971).

Schmela (1971) studied the physiography of the Portland area and completed some gravity and magnetic measurements southeast of Portland. Although he did not attempt quantitative interpretation of his geophysical data, he suggested that there has been vertical offset (down to the east) in the Columbia River Basalt along the Portland Hills Fault zone.

The gravity of Oregon was interpreted on a regional scale by Thiruvathukal (1970). Wavelengths of anomalies were analysed and they showed that the steep gravity gradient apparent in the state Bouguer gravity map (figure 4) going east across the state is due to crustal thickening. Crustal thicknesses were seen to vary from 20 kilometers in the Coast Range to 45 kilometers in eastern Oregon. This work also indicates that the anomalies observed in the Portland area and the Tualatin Valley are related to near surface structural features, due to their short wavelengths.

DESCRIPTION OF FIELD WORK

Field work was done in Winter 1975-1976 and Spring 1976. The gravity readings were taken with a Worden gravimeter on loan from the School of Oceanography, Oregon State University. An absolute gravity station was established by Wollard (1958) at the Portland International Airport and has a value of 980648.24 milligals (10^{-3} cm/s^2). This station was transfered to the Earth Science Department at Portland State University which has an absolute gravity of 980641.35 milligals (Beeson _et al_., 1975). Instrument scale corrections were made for small temperature variations although the temperature was closely controlled by a thermostat. The instrument sensitivity of $\pm$ .02 milligals was more than adequate for this study.

Drift control was obtained by occupying the Portland State University absolute gravity station before and after each day in the field. A field base station was also occupied immediately upon arriving in the field in the morning and reoccupied several times during each day.

Elevation control was established using several methods which are described in table 1 below along with the estimated elevation error. The datum plane used was that of the U.S. Coast and Geodetic Survey. Corrections were applied for control points which used different datum planes (Appendix II). Bench marks in the area are described in Appendix III.

TABLE 1

Stations	Method of Elevation Control	Error Elevation	Error Gravity
1-69	Surveying with transit and level between bench marks.	± .6	± .069 mgals
101-111	City of Portland and Oregon State Highway Department bench marks.	± 0 meters	± 0 mgals
201-238	Two foot contour interval maps (scale 1:1200) of the cities of West Linn and Lake Oswego.	± 1.2 meters	± .138 mgals
301-308	U.S. Geological Survey 7.5', 10 foot contour interval maps; Canby and Sherwood quadrangles.	± 6 meters	± .69 mgals

Stations 70-100, 112-200, 239-300 not occupied.

DATA REDUCTION

All data reduction in this study was done with a computer program written for this purpose with the exception of terrain and drift corrections. This program is described in Appendix IV. Drift corrections were made by constructing a drift curve for each day in the field on the basis of the Portland State University base station and field base station readings. This method is described in more detail by Dogrin (1976).

Terrain corrections were done using the Hammer charts and the technique described in Dobrin (1976. pp. 419-423), in conjunction with the associated U.S. Geological Survey topographic maps of the area. Corrections were computed for zones D through M using the appropriate scale maps. The correction tables given in Dobrin (1976; p. 423) are computed for a surface density of 2.0 gm/cm^3, so all terrain corrections were adjusted to a density of 2.67 gm/cm^3 to correlate with the standard complete Bouguer anomaly. Terrain corrections were computed for every fifth station; intermediate terrain corrections were obtained by extrapolation.

The data reduction computer program used the international gravity formula and the standard Bouguer and free air corrections as given in Dobrin (1976). The program described an Appendix V reduces the data and plots the free air anomaly, Bouguer anomaly, and elevation for rapid comparison and examination for data reduction errors.

An additional correction was applied to all gravity data points for the difference between the density of the rock unit above sea level and 2.67 gm/cm^3 as used in the Bouguer anomaly. The regional gradient was also corrected for in the gravity modeling programs described in Appendices VI and VII by subtracting out a gradient as a function of distance along an east-west line. The regional gradient used in this study was 1.2 milligals/kilometer to the east based on Berg and Thiruvathukal (1967, figure 4). The crustal thickening related to the transition between oceanic to continental crust going inland along the continental margin causes a rapid decrease in the Bouguer gravity due to the thickened section of low density continental crust which must be corrected for before the upper crustal anomaly may be accurately modeled. Thiruvathukal et al. (1970) use a filter function to separate the gravity anomalies on the basis of their wavelengths and relate them to the depth of the source. This work indicates that the anomalies observed in the Portland area are related to near surface features and may be modeled independently of the larger scale crustal structure.

The reduced data for this line is given in the computer print out in the pocket (GRAVREDUC, Appendix IV). The free air anomaly and complete Bouguer anomaly were used for modeling purposes. Anomalies are reported to thousandths of milligals, but measurement accuracy is considerably less. Error estimations for the detailed portion of the line are as follows:

Elevation error	$\pm$ .14 milligal
Latitude error	.02
Instrument reading	.02
Terrain correction	.05
Drift correction	.05

Elevation related error for stations 301-308 is significantly larger than for the other stations due to the lack of adequate elevation control.

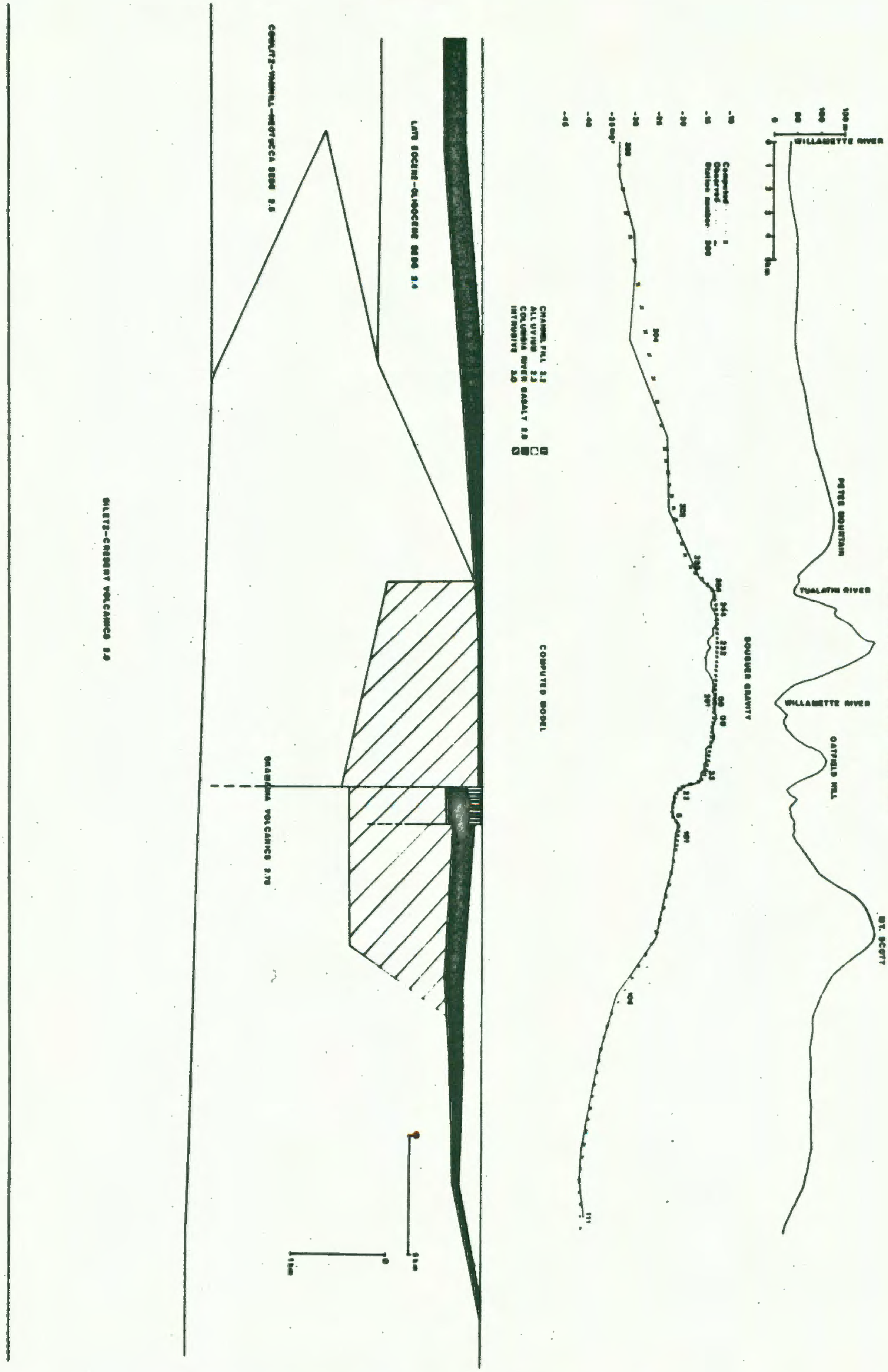
The maximum error possible from the above sources is $\pm$ .28 milligals per station. Since these error sources are independent a more realistic estimation of the expected error may be obtained from $\sqrt{\Sigma e^2}$ where e is the error due to each source (A.G. Johnson, L.G. Swanson, personal communication, 1977). This formula indicates that most stations are accurate to $\pm$ .16 milligals.

QUANTITATIVE INTERPRETATION OF GRAVITY ANOMALIES

The gravity anomalies were interpretated using free air and Bouguer modeling computer programs adapted to the Portland State University computer system from programs used at Oregon State University. The basic algorithm for these programs was developed by Talwanic et al. (1959). Descriptions of these programs are given in Appendices VI and VII. Geologic control for the gravity modeling was provided by Trimble's (1963) geologic map of the Portland area shown in figure 2, well logs and interpreted cross section in the Portland area (Newton, 1969; figure 1), detailed geologic mapping of south Portland (Beeson et al., 1975) shown in figure 3, and recent gravity studies by Beeson et al. (1975), Johnson (1975), Donovan (1976), and Jones et al. (1977). The procedure for gravity modeling was to construct a subsurface geologic cross section which was consistent with all available information and the best avalaible densities for the rock units. Models were constructed only to five kilometers depth as geologic control does not extend below this point and the near surface structure is predominant in detailed modeling. Models were also extended for 100 kilometers on each end of the line to avoid edge effects. Densities were primarily obtained from Bromerly and Snavely (1964), and Beeson et al. (1975), and are given in Appendix I. The densities are estimates only as the formation density may differ significantly from a sample density. However in modeling the density contrast alone is significant. The Bouguer anomaly of the model was then computed with the Bouguer modeling program and the calculated anomaly compared to the measured Bouguer anomaly. Adjustments were made in the models in places where the calculated anomaly failed to match the measured anomaly. Such adjustments could be made in the formation thickness, formation density, and subsurface structure, so a certain amount of ambiguity is inevitable. However, by trying many different models it is possible to arrive at a few which best fit all the parameters, and ultimately one which is tentatively accepted. The accuracy of the gravity model is directly related to the accuracy of the geologic control available. Fortunately in this case the control is such that most aspects of the final model are believed to be quite accurate. Unique solutions are of course impossible using any potential method, but certain models may be found to be impossible, whereas others may be found to be acceptable.

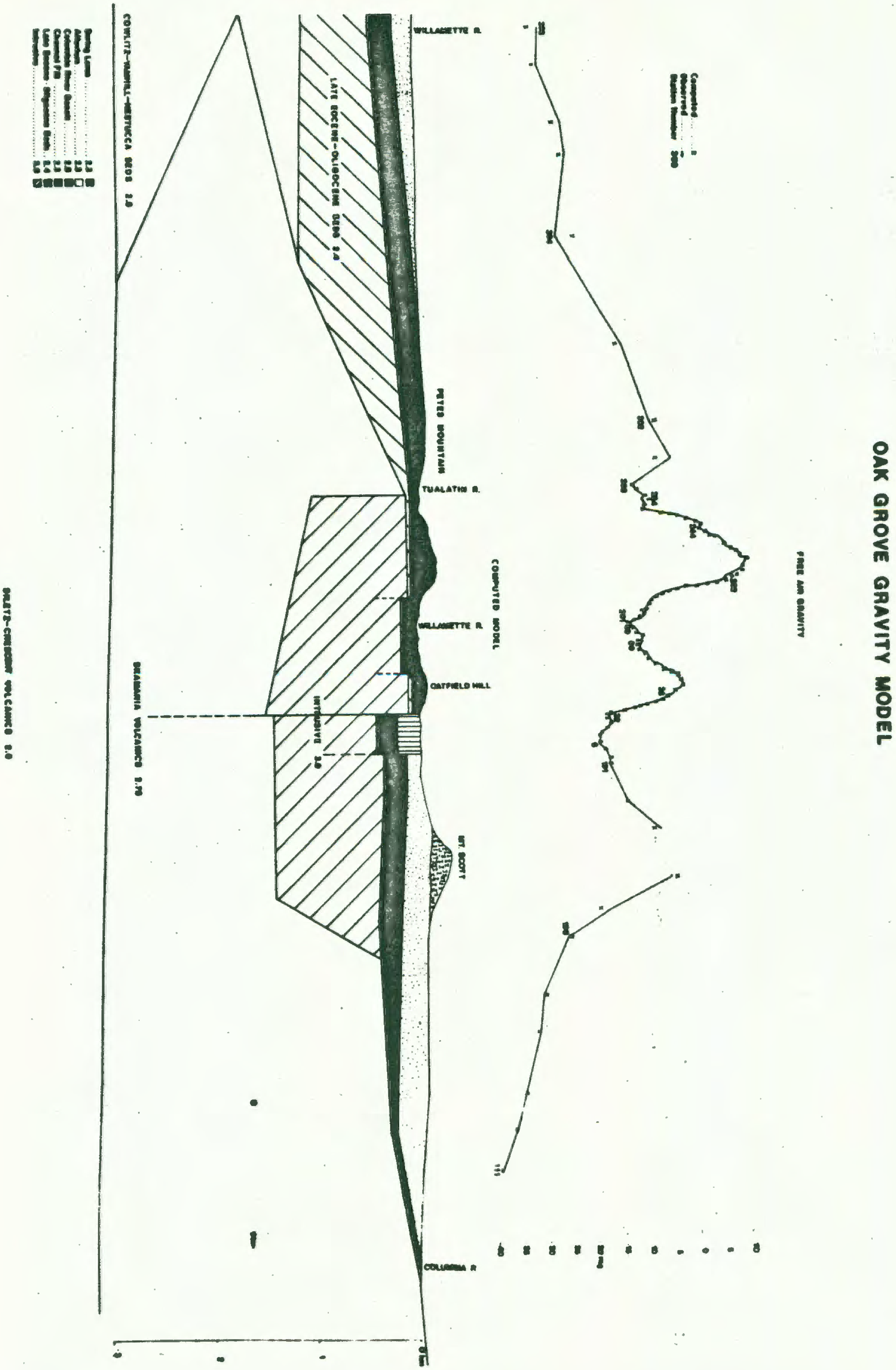
After the Bouguer anomaly was fitted as closely as possible, the free air anomaly was modeled using the free air modeling program. This required inclusion of the topography above sea level which is not included in the Bouguer program. Although the free air anomaly allows a more accurate fit to the data, it is extremely difficult to work with due to its increased complexity and the absence of a model check as in the Bouguer modeling program which locates construction errors in the model program as input into the computer. By modeling the Bouguer anomaly first, the free air modeling process was greatly simplified because the model has already been considerably refined. In this case the bast fit obtained using the Bouguer model still has significant areas which failed to match as seen in figure 6. When this model was adjusted slightly using the free air modeling program,

FIGURE 6


OAK GROVE GRAVITY MODEL
WILLAMETTE RIVER
PETES MOUNTAIN
TUALATIN RIVER
WILLAMETTE RIVER
OATFIELD HILL
MT. SCOTT
BOUGUER GRAVITY
COMPUTED MODEL
CHANNEL FILL
ALLUVIUM
COLUMBIA RIVER BASALT
INTRUSIVE
SILETZ-CRESCENT VOLCANICS

a significantly better fit was obtained with almost no change in the subsurface structure. The free air anomaly and associated model are shown in figure 7. This suggests that most of the residual present in the final Bouguer model is due to the topography above sea level which is very difficult to quantitatively account for without the free air program. It must be noted however, that these modeling algorithms compute the anomaly based on a two-dimensional profile, and assume all features to be continuous in the third dimension. Thus any feature which has predominantly cylindrical symmetry may introduce small errors into the modeling process.

FIGURE 7



OAK GROVE GRAVITY MODEL
FREE AIR GRAVITY
COMPUTED MODEL
WILLAMETTE R.
PETES MOUNTAIN
TUALATIN R.
WILLAMETTE R.
OATFIELD HILL
MT SCOTT
COLUMBIA R
LATE EOCENE-OLIGOCENE SEDS 2.4
COWLITZ-YAMHILL-NESTUCCA SEDS 2.5
INTRUSIVE 2.9
SKAMANIA VOLCANICS 2.70
SILETZ-CRESCENT VOLCANICS 3.0

DISCUSSION OF GRAVITY MODELS

The final free air and Bouguer gravity models and the comparison of the computed gravity to the measured gravity anomalies are shown in figures 6 and 7. Coordinates of the models and their calculated gravity anomalies are given in the computer print out in the pocket (BOUGUERFIT and FREEAIRFIT). Perhaps the most striking feature of both gravity profiles is the large (approximately 10 milligal by 20 kilometer) gravity high in the center of the profiles where the line crosses the northern extension of the gravity high on the state Bouguer gravity map (see figure 4). Geographically the anomaly is centered over the main Portland Hills trend. This feature is most apparent on the Bouguer profile as the free air profile is more influenced by the topography. On either side of the gravity high the anomaly decreases gently and uniformly. In the modeling procedure the first model was constructed to fit as simply as possible the well log and surface geologic data. Modifications of this scheme were made as required by the gravity data while remaining consistant with all available geologic control. However no wells penetrate below the Columbia River Basalt in this area to provide information on the source of this anomaly. Several attempts were made to model this feature, and the only one which fit all available data used a shallow sheet-like high density intrusion directly beneath the Columbia River Basalt and underlying most of the Portland Hills and Portland Basin, as illustrated in figures 6 and 7. The density and shape of the intrusion are somewhat arbitrary as there is no geologic control on this body, but the models shown best fit the gravity data and were geologically the most reasonable. The density of the intrusion must be significantly larger than 2.78 gm/cm^3 or there would not be sufficient contrast between the intrusion and the Skamania volcanics to give a large gravity high. The size of the anomaly also rules out the possibility that it may be explained by some configuration of the Skamania volcanics and the overlying sediments or a thickened section of Columbia River Basalt. The lateral extension of the intrusion is controlled by the sharp edges of the anomaly, indicating it to be about 20 kilometers wide. The wavelengths of the edges of the anomaly require it to be located directly beneath the Columbia River Basalt. A density of 3.0 gm/cm^3 was chosen as an average value for a mafic intrusive body, and based on this assumption the thickness was found to be approximately one kilometer. Any reasonable value of density would yield similar results. The intrusion is believed to be mafic in composition due to the widespread occurrence of the basaltic Boring volcanics in this area.

The geometry of the Portland Basin to the east of the Portland Hills and the Tualatin Valley to the west are also shown in figures 6 and 7. The structure is more complex than a simple anticline in the Columbia River Basalt with synclines on either side. A fault offsetting the Columbia River Basalt with vertical offset (down to the east) of about 300 meters is required to match the gravity anomaly near station 22. This fault is interpreted as cutting the intrusive body into two sections, with the eastern one significantly thinner. Another smaller fault further to the east in the Portland Basin is indicated by the anomaly near station 6 with about 50 meters vertical offset (down to the west) forming an alluvial filled graben. A small stream now occupies this area, but it may have been the former course of the Willamette River (Trimble, 1963).

In the free air model (figure 7) a graben structure in the Columbia River Basalt is shown centered under the Willamette River. This structure is not required by the gravity anomaly, but was included because detailed correlation and mapping of individual basalt flows in the area by Beeson et al. (1975) indicate its presence. It is consistant with the gravity anomalies provided that a thin layer of sediment is included between the Columbia River Basalt and the intrusion as shown in the model. A well log in the Oregon City area slightly to the south of the Oak Grove line penetrated about 15 meters of sediment beneath the Columbia River Basalt when drilling ceased substantiating this possibility (Hogenson, 1965).

Another interesting feature in the model of this line is the thinning to the east and pinchout observed in the Eocene-Oligocene sedimentary rocks beneath the Tualatin Valley. Large density contrasts between the sedimentary and volcanic units allow this contact to be located with some precision. This pinchout was also observed in the three lines to the north by Beeson et al. (1975) and they all fall roughly along a north-south line, suggesting that the predominant structural trend prior to Eocene time was aligned in a north-south direction. The Skamania volcanic high located between the sedimentary pinchout and the intrusion may represent a paleo-topographic high. The present location of the intrusion may thus have been an ancient sedimentary basin. The sedimentary units might have been more easily assimilated or displaced by the magma than the Skamania volcanics, and thus the paleo-structure and stratigraphy may have been a factor controlling the emplacement of the magma body.

The presence of the intrusion is believed to be related to the occurrence of the Broing vents in this area (see figure 2). Possibly the intrusion may represent the source of the Boring volcanics. The gravity high on the state Bouguer gravity map (figure 4) corresponds closely to the Boring vents as mapped by Trimble (1963). The Oak Grove gravity line in this study passes along the north edge of the gravity high shown on the state map (figure 4). The main part of this anomaly has not been investigated in detail. If this high is associated with the intrusion and the Boring vents which are also more extensive to the south of this line, then the bulk of the intrusion and probably its source lies further to the south. This suggests an area for further study. The best available dates on the Boring vents place them at 1-2 million years before present (Trimble, 1963). The large surface area to volume ratio of the intrusion as modeled in the Oak Grove line (note the 4:1 vertical exaggeration in figures 6 and 7) suggests that the intrusion has probably cooled. However, if the intrusion is significantly larger to the south then it may still retain some heat, of possible interest for geothermal exploration.

The presence of the intrusion also suggests a possible cause for the graben structure and other minor faulting shown in figure 3. Beeson <u>et al</u>. (1975) believe that the Portland Hills in this area were formerly an anticline in the Columbia River Basalt which has subsequently collapsed. Cooling and contraction or withdrawl of the magma may have caused the graben collapse structure.

One feature of the gravity model which is not known to any degree of precision is the contact between the Skamania volcanics and the Siletz-Crescent volcanics, which presumably have nearly the same density and thus are impossible to distinguish in interpretation of a gravity anomaly.

It must be noted that the Bouguer model in figure 7 has several areas which have significant residuals between the calculated and observed gravity. A prominant three milligal low in the measured anomaly is observed centered on station 232. No attempt was made to model this feature as there was no evidence for any low density body in this area. When the free air anomaly of this model was calculated nearly all of this residual disappeared. Several other smaller residuals in the Bouguer model disappeared when the free air anomaly was calculated. This indicates that these features are primarly due to the topography. For stations 301-308 no attempt was made to model the anomaly exactly as the elevation control in this area was insufficient to justify further effort.

A residual in the final Bouguer and free air model fit is also observed in the area of stations 102-106. Several sources for this feature are possible. These stations are located directly over Mt. Scott, a Boring vent. Although the Boring volcanics appear to consist of basaltic type lava flows, gravity data indicates that Mt. Scott and other Boring vents in the Portland area have an average density of about 2.3 gm/cm^3, suggesting it may be predominantly pyroclastic material. Local variations in texture of the rock within the vent could cause substantial changes in density and hence in gravity anomalies over it. Mt. Scott also represents one of the steeper and more irregular topographic features encountered in this line and its shape and gravity anomaly are defined by only four stations; thus volumetric uncertainties could represent part of the source of the residual. Another possibility is the aforementioned assumption in the modeling algorithm that all geometric features are continuous perpendicular to the trend of the model cross section. In the case of Mt. Scott, however this is obviously not true, causing the calculated anomaly to be slightly larger than it should be.

IMPLICATIONS OF GRAVITY MODELS

The implications of the gravity models for the regional tectonics of the Portland area have been reviewed in greater detail by Beeson et al. (1975), Donovan (1976), Johnson (1975), Johnson and Jones (1976), and Jones et al. (1977). Discussion is included here in order to examine these conclusions in the light of this new data.

The detailed gravity surveys in the Portland area have been summarized by a one milligal contour interval Bouguer gravity map (Perttu (formerly Donovan), in preparation, 1977). Modeling by Perttu (personal communication, 1977) and Beeson et al. (1975) indicate the intrusion is present trending north through the Portland Basin and northwest along the Portland Hills trend and is intimately associated with the gravity high on the state Bouguer gravity map (figure 4).

Evidence for the Portland Hills Fault zone has been summarized by Beeson et al. (1975). This evidence indicates that the Portland Hills Fault zone is essentially a right-lateral strike-slip fault zone with 15-20 kilometers of right-lateral displacement since Eocene time with locally up to 300 meters vertical displacement. This correlates with first motion focal mechanism solutions of Portland area earthquakes (Couck and Lowell, 1971). Although left-lateral movement along a northeast trending fault is also possible, there is no evidence of such a fault zone in the gravity map.

The right-lateral movement along a strike-slip fault zone bounding the east side of the Portland Hills fits seismic data (Couch and Lowell, 1971), physiography (Schmela, 1971), structural geology of the area (Beeson et al., 1975; Balsillie and Benson, 1971), field mapping (Beeson et al., 1975; Anderson, 1977), and gravity data (Beeson et al., (1975); Johnson, (1975); Donovan, (1976); Johnson and Jones, (1976); and Jones et al., (1977). It must be noted that neither vertical movement along a normal or reverse fault, nor left-lateral movement along a northeast trending strike-slip fault (such as the proposed Yamhill-Bonneville linement) fits these lines of evidence equally well. As a matter of speculation, the Portland Hills Fault zone may represent an extension of the same structural zone as the Brothers Fault zone in central Oregon (Lawrence, 1976), although any connection between the two is obscured under the younger Cascade volcanics.

The intrusion appears to be controlled in part by the Portland Hills Fault zone thus the fault zone may represent a line of weakness into which the intrusion was implaced. The gravity high extends northward into the Portland Basin, diverging from the Portland Hills Fault zone, and the intrusion is required to model the gravity anomaly there (Perttu, personal communication, 1977). Thus the intrusion may also be controlled by the paleo north-south structure of the Skamania volcanics. The intrusion also appears to continue northwest under the Portland Hills parallel to the Portland Hills Fault zone for several kilometers and is seen in the Sellwood line (Beeson et al., 1975; figure 5).

The Oak Grove model shows the intrusion to be thinner to the east of the fault than to the west. If the source of the intrusion is to the south of this line as indicated by the more extensive gravity anomaly there and it thins to the north as the other models indicate (Beeson _et al_., 1975) then this could represent additional evidence for right-lateral movement along this zone. The Sellwood line to the north (figure 5) shows a small intrusion to the west of the fault, and none at all to the east.

CONCLUSIONS

Quantitative interpretation of gravity anomalies in the Oak Grove line has yielded several important results. A large high density intrusion spacially associated with the occurrence of the Boring vents south of Portland and in the Portland Basin is required to model the gravity high. Regional gravity maps (figure 4) indicate this intrusion may be larger to the south where the gravity anomaly is more extensive. A fault zone with up to 300 meters of vertical displacement (down to the east) is also required along the east side of the Portland Hills with a smaller fault further to the east forming a graben structure. The shape of the Portland Basin is modeled as a broad syncline in the Columbia River Basalt flattened at the bottom. The eastern portion of the Tualatin Valley was also modeled as a syncline in the Columbia River Basalt flattened at the bottom. The thinning and pinchout of the Eocene-Oligocene sediments is near the west side of the Portland Hills in this location. The intrusion is cut by the fault and appears to be offset in a right-lateral sense if the assumption that the intrusive body thins to the north is justified. Right-lateral movement along a northwest trending fault zone bounding the east side of the Portland Hills is consistant with stress conditions and source mechanism solutions from first motion analyses of northwest Oregon earthquakes (Couch and Lowell, 1971). This conclusion has also been reached by Beeson et al. (1975), Johnson and Jones (1976), and Perttu (personal communication, 1977).

The intrusion is believed to be a source for the Plio-Pleistocene eruption of the Boring vents in the Portland area, and its cooling or withdrawl may be responsible for the collapse structure observed in south Portland where mapping of individual basalt flows has been completed (Beeson et al., 1975).

Additional work is needed to the south to define and model the gravity high indicated on the state Bouguer gravity map (figure 4). Also of interest in this area is the structural control on the Boring vents. Gravity surveys in the Tualatin Valley are needed to further define its depth and shape. Gravity surveys north of Portland along the Portland Hills trend should help to define the length of the Portland Hills Fault zone as would further surveys to the south in the Clackamas River area. Seismic monitoring has been initiated to investigate the present activity along the Portland Hills Fault zone and has yielded positive results to date; this work should be continued and expanded.

REFERENCES CITED

Anderson, J. L., 1977, Stratigraphy and structure of the Columbia River Basalts in the Clackamas River area (abs.): Oregon Academy of Sciences, (in press), February, 1977.

Baldwin, E. M., 1964, Geology of Oregon, 2d ed.: Ann Arbor, Mich., Edwards Bros., Inc., 165 p.

Balsillie, J. H., and Benson, G. T., 1971, Evidence for the Portland Hills Fault: The Ore Bin, V. 33, no. 6, p. 109-118.

Beeson, M. H., Johnson, A. G., Benson, G. T., 1975, Portland Environmental Geology-Fault Identification; semi-annual technical report to the U. S. Geological Survey, 59 p.

Beeson, M. H., Johnson, A. G., Moran, M. R., 1975, Portland Environmental Geology-Fault Identification; final technical report to the U. S. Geological Survey, 107 p.

Beeson, M. H., Moran, M. R., Johnson, A. G., 1977, Fault identification and structural evolution of the Portland area (abs.): Oregon Academy of Sciences, (in press), February, 1977.

Benson, G. T., Beeson, M. H., Johnson, A. G., 1976, Structure of the Tualatin Mountains, Portland, Oregon (abs.): Proceedings of the Geological Society of America, March, 1976.

Berg, J. W., Jr., and Baker, C. D., 1963, Oregon earthquakes, 1814 through 1958: Seismol. Soc. Am. Bull., v. 53, p. 95-108. (Condensation in the Ore Bin, V. 24, no. 9, p. 143-149, 1962.)

Berg, J. W., Jr., and Thiruvathukal, J. V., 1965, Gravity base station network, Oregon: Jour. Geophy. Research, V. 70, p. 3325-3330.

_____ 1967a, Free-air gravity anomaly map of Oregon: Oregon Dept. Geology and Mineral Industries Map GMS-4a.

_____ 1967b, Complete Bouguer gravity anomaly map of Oregon: Oregon Dept. Geology and Mineral Industries Map GMS-4b.

Bromery, R. W., and Snavely, P. D., Jr., 1964, Geologic interpretation of reconnaissance gravity and aeromagnetic surveys in northwestern Oregon: U. S. Geol. Survey Bull, 1181-N, p. N1-N13.

Couch, R., Johnson, S. and Gallagher, J., 1968, The Portland earthquake of May 13, 1968 and earthquake energy release in the Portland area: The Ore Bin, v. 30, no. 10, p. 185-190.

Couch and Lowell, R. P., 1971, Earthquakes and seismic energy release in Oregon: The Ore Bin, V. 33, no. 4, p. 61-84.

Davis, J. C., 1973, Statistics and Data Analysis in Geology, New York, John Wiley & Sons, Inc., 550 p.

Dehlinger, P., and Berg, J. W., Jr., 1962, The Portland earthquake of November 5, 1962: The Ore Bin, v. 24, no. 11, p. 185-188.

Dehlinger, P., Bowen, R. G., Chiburis, E. F., and Westphal, W. H., 1963, Investigations of the earthquake of November 5, 1962, north of Portland: The Ore Bin, V. 25, no. 4, p. 53-68.

Diller, J. S., 1896, A geological reconnaissance in the northwestern Oregon: U. S. Geol. Survey 17th Ann. Rept., pt. 3, p. 441-520.

Dobrin, M. B., 1976, Introduction to Geophysical Prospecting: New York, McGraw-Hill Book Co., Inc. 630 p.

Donovan, J. C., Johnson, A. G., 1976, A preliminary interpretation of gravity data in east Portland, Oregon (abs.): Transactions, American Geophysical Union, September, 1976.

Harris Corporation, 1976, General Specification-Harris fortran compiler-revision C: Harris Corporation, Fort lauderdale, Florida.

_____ 1976, Reference Manual-vulcan system services: Harris Corporation, Fort lauderdale, Florida.

Heinrichs, D. F., and Pietrafesa, L. J., 1968, The Portland earthquake of January 27, 1968: The Ore Bin, V. 30, no. 2, p. 37-40.

Hogenson, G. M., and Foxworthy, B. L., 1965, Ground water in the east Portland area, Oregon: U. S. Geol. Survey Water-Supply Paper 1793, 78 p.

Johnson, A. G., 1975, Gravity profiles across the northeast side of the Tualatin Mountains, Portland, Oregon (abs.): Transactions, American Geophysical Union, December, 1975, p. 89.

_____ 1976, Microearthquakes near Portland, Oregon (abs.): Transactions, American Geophysical Union, September, 1976.

Johnson, A. G., Jones, T. D., 1976, Gravimetric investigation of the Tectonics of the Portland Hills (abs.): Transactions, American Geophysical Union, December, 1976.

Jones, T. D., Perttu, J. D., Johnson, A. G., 1977, Interpretation of gravity in the Portland area (abs.): Oregon Academy of Sciences, (in press), February, 1977.

Lawrence, R. D., 1976, Strike-slip faulting terminates the Basin and Range province in Oregon: Geol. Soc. America Bull., v. 87, no. 6, p. 846-850.

Mann, R. A., 1974, An IBM 1130 Primar, Intext, Inc., New York.

McCracken, D. D., 1972, A guide to fortran IV programming, New York, John Wiley & Sons, Inc., 288 p.

Nettleton, L. L., 1976, Gravity and magnetics in oil prospecting, New York, McGraw-Hill Book Co., Inc., 464 p.

Newton, V. C., Jr., 1969, Subsurface geology of the lower Columbia and Willamette Basins, Oregon: Oregon Department of Geology and Mineral Industries, 121 p.

Portland State University Computing Services Center, 1976, Harris 220 users guide, Portland State University, Portland, 62 p.

Rinehart, W., Bower, R. G., and Chiburis, E. F., 1964, Airport gravity base station network in Oregon: The Ore Bin, V. 26, no. 3, p. 37-56.

Schlicker, H. G., Deacon, R. J., and Twelker, N. H., 1964, Earthquake geology of the Portland area, Oregon: The Ore Bin, V. 26, no. 12, p. 209-230.

Schmela, R. J., 1971, Geophysical and geological analysis of a fault-like linearity in the lower Clackamas county, Oregon: Portland State University masters thesis, 113 p.

Snavely, P. D., Jr., and Wagner, H. C., 1964, Geologic sketch of northwestern Oregon: U. S. Geol. Survey Bull. 1181-M, p. M1-M17.

Talwani, M., Worzel, J. C., landisman, M., 1959, Rapid gravity computations for two-dimensional bodies with application to the Mendocine submarine fracture zone: Jour. Geophys. Res., v. 64, no. 1, p. 49-59.

Texas Instruments Incorporated, 1963, Worden gravity meter operating instruction manual n. 81537-5: Texas Instruments Inc., Houston, Texas, 89 p.

Thiruvathukal, J. V., Berg, J. W., Jr., and Henricks, D. F., 1970, Regional gravity of Oregon: Geol. Soc. America Bull., v. 81, no. 3, p. 725-738.

Treasher, R. C., 1942, Geologic history of the Portland area; Oregon Dept. Geology and Mineral Industries Short Paper 7.

Trimble, 1957, Geology of the Portland quadrangle, Oregon and Washington: U. S. Geol. Survey Quadrangle Map GQ-104.

_____ 1963, Geology of Portland, Oregon and adjacent areas: U. S. Geol. Survey Bull. 1119, 119 p.

Walker, G. W., and King, P. B., 1969, Geologic map of Oregon: U. S. Geol. Survey, Map 1-595.

Wells, F. G., and Peck, D. L., 1961, Geologic map of Oregon west of the 121st meridian: U. S. Geol. Survey Misc. Geol. Inv. Map 1-325, scale 1:500,000.

Westphal, W. H., 1962, Seismic aftershock investigations--Project Vela, Portland, Oregon earthquake of November 6, 1962: Stanford Research Institute, Tech. Rept. 1, 11 p.

Woollard, G. P., 1958, Results for a gravity control network at airports in the United States: Geophysics, v. 23, no. 3, p. 520-535.

Zietz, I., Hearn, B. C., Jr., Higgins, M. W., Robinson, G. D., Swanson, D. A., 1971, Interpretation of an aeromagnetic strip across the northwestern United States: Geol. Soc. America Bull., v. 82, no. 12, p. 3347-3371.

APPENDICES

APPENDIX I

Lithologic descriptions of units used in gravity modeling.

Siletz-Crescent Volcanics

The Siletz-Crescent Volcanics are described by Snavely and Wagner (1964) as a thick sequence of lower to middle Eocene basaltic pillow lavas and volcanic breccias. These units are not important in the modeling of the Oak Grove gravity line as there is little geologic control available on them. A density of 2.8 gm/cm^3 for this unit is from Beeson et al. (1975).

Skamania Volcanics

The Skamania Volcanics are described by Trimble (1963) as a series of altered basalt and basaltic andesite flows and associated pyroclastic rocks. They are present in the well logs by Newton (1969) and are thought to be exposed in a small highly weathered outcrop several kilometers south of the area studied. The density of 2.78 gm/cm^3 is from Beeson et al. (1975).

Cowlitz-Yamhill-Nestucca Sediments

These units do not outcrop in the Portland area. They are described by Snavely and Wagner (1964) as middle to late Eocene tuffaceous marine sandstones and siltstones. The density is given by Beeson et al. (1975) as 2.5 gm/cm^3.

Late Eocene-Oligocene Sediments

These rocks also do not crop out in the Portland area, but are present in the well logs by Newton (1969). They consist of tuffaceous marine sediments (Snavely and Wagner, 1964). The density of 2.4 gm/cm^3 is from Beeson et al. (1975).

Columbia River Basalt

The middle Miocene Columbia River Basalts underlie essentially the entire area studied but crop out only along the Portland Hills and in the lower Clackamas River area. Thicknesses vary widely as seen in the gravity models. The Barber well log (Newton, 1969) intersects about 200 meters of Columbia River Basalts. Models indicate the basalt is nearly 350 meters thick in the Portland Basin, and thins to about 70 meters on the east edge of the Basin. The density of 2.8 gm/cm^3 is from Beeson et al. (1975).

Alluvium

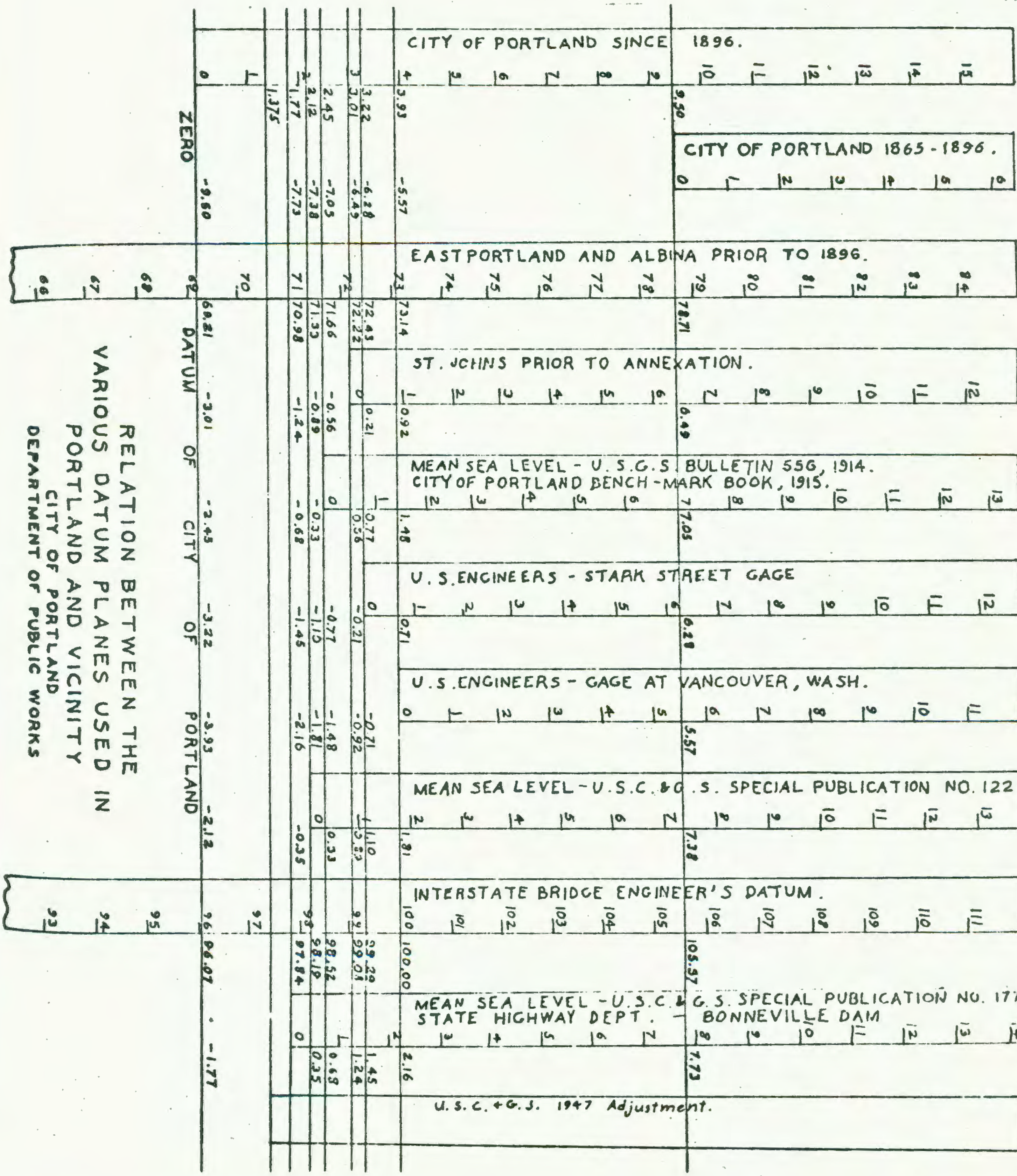
The area designated as alluvium on the gravity models consists of recent alluvium, Troutdale Formation, and Sandy River Mudstone which were grouped together for modeling purposes due to their similar densities. The alluvium consists of sand, silt, and gravel deposites of Pleistocene or recent age. The area designated as channel fill on the gravity models is probably a deposit of unconsolidated alluvium deposited when the Willamette River took this course (Trimble, 1963). The lower Pliocene Troutdale Formation consists mainly of sandstone of variable composition and conglomerate. The Sandy River Mudstone is an early Pliocene deposit of varying lithology including sand, shale, clay and silt (Trimble, 1963). The density of 2.3 gm/cm^3 for these units was obtained from Beeson et al. (1975).

Boring Lavas

The Boring lavas were described and named by Threasher (1942) as Plio-Pleistocene basaltic lava flows and pyroclastic rocks. Eruptive vents are present in the Portland Basin, along the Portland Hills trend, and are prevalent in the area south of this study to the southeast of Oregon City. Thicknesses vary widely as a function of distance from a source vent but may reach nearly a hundred meters.

Sample densities are not available for the Boring lavas and would not be of much use due to the large amount of pyroclastic material associated with the lava flows. It was noted in this study and the one by Donovan (1976) that the prominant Boring vents are often associated with lows in the Bouguer gravity anomaly. Modeling in this study indicates an overall density of about 2.3 gm/cm^3 for the Boring vents.

APPENDIX 11


CITY OF PORTLAND SINCE 1896.
CITY OF PORTLAND 1865 - 1896.
EASTPORTLAND AND ALBINA PRIOR TO 1896.
ST. JOHNS PRIOR TO ANNEXATION.
MEAN SEA LEVEL - U.S.G.S. BULLETIN 556, 1914.
CITY OF PORTLAND BENCH-MARK BOOK, 1915.
U.S. ENGINEERS - STARK STREET GAGE
U.S. ENGINEERS - GAGE AT VANCOUVER, WASH.
MEAN SEA LEVEL - U.S.C.&G.S. SPECIAL PUBLICATION NO. 122
INTERSTATE BRIDGE ENGINEER'S DATUM.
MEAN SEA LEVEL - U.S.C.&G.S. SPECIAL PUBLICATION NO. 177
STATE HIGHWAY DEPT. - BONNEVILLE DAM
U.S.C.+G.S. 1947 Adjustment.
ZERO DATUM OF CITY OF PORTLAND
RELATION BETWEEN THE
VARIOUS DATUM PLANES USED IN
PORTLAND AND VICINITY
CITY OF PORTLAND
DEPARTMENT OF PUBLIC WORKS

APPENDIX III

DESCRIPTION OF BENCH MARKS IN THE THESIS AREA

City of Portland Bench Marks

Elevation (feet)	Description
667.05	BM 87-Brass disk in southwest corner of southernmost intersection of Mt. Scott Blvd and 112th Ave., in west curb three feet inside Lincoln Memorial Cemetery.
430.51	BM 95-Brass disk in south side of driveway on west side of 122nd St., north of Flavel St., and south of intersection of 122nd and Henderson St.
273.70	BM 337-Brass disk in concrete platform next to flagpole at fire station on southwest corner of intersection of Forster and Deardorff Rd. (132nd).
245.97	BM 888-Brass disk in curb at southwest corner of intersection of SE Division and Barber Rd. (162nd).
244.35	BM 1025-Brass disk in curb at southwest corner of intersection of SE Gladstone and 151st.
250.06	BM 850-Brass disk in curb at northwest corner of intersection of E Burnside and NE 181st.
205.34	BM 893-Brass disk in east curb of 190th Ave., about 30 feet south of intersection of Halsey St. and 190th.
82.77	BM 4066-Brass disk at northwest corner of intersection of NE Sandy Blvd. and 201st.

Clackamas County Bench Marks

Elevation (feet)	Description
138.52	BMH 597-on southeast corner of Lake Road on over-pass of 82nd freeway.
139.07	BMG 594-on northwest corner of Lake Road on over-pass of 82nd freeway.
112.663	4438A-on west curb on Tiara Drive about 30 feet south of Lake Road.
105.09	4437-in curb at northeast corner of Clackamas High School.
87.243	4436A-in catch basin on north side of Parmenter Court about 100 feet east of Kellogg creek.
88.885	4536C-in concrete gutter--northeast corner of Kellogg Court at Aldercrest Road.
213.830	4536B-West curb in church parking lot about 30 feet north of Thiessen and about 100 feet east of SE Vista Lane.
154.20	4537A-on intersection of Thiessen and Webster in curve at Chevron Station.
100.153	4537B-in southeast curb at intersection of Alder-crest and SE Molt.
353.905	4636A-in curb at southwest corner of intersection of Naef and Wallace.
310.730	4636C-in curb on north side of View Crest Dr. 200 feet southwest of Narma Road.
292.95	4636B-in northwest corner of catch basin on north side of McNary Road at Ormae Road.
290.104	4240A-in retaining wall near southwest corner of Top'O'Scott clubhouse.
201.718	4240B-in east curb of SE 91st. Ave. about 40 feet south of Sunnyside Road.
556.506	4141A-in footing for retaining wall over ditch on west side of driveway about 50 feet west of PGE #5486 on north side of Hillcrest Drive.

Oregon State Highway Commission Bench Marks

Elevation (feet)	Description
59.586	53 feet north from northeast corner of Oregon Worsted Company plant at SE Mcloughlin Blvd. and SE Umatilla St., southeast corner of Southern Pacific Company railroad bridge 765.46 over Johnson Creek, top of retaining wall.
99.419	Intersection of SE 37th Ave. and Portland Electric Power Company track, 18 feet north of track, 4 feet west of station. Cap stamped "200" on iron pipe.
194.373	.3 miles south of Portland city limit, northeast corner of SE 82nd Ave bridge over Johnson Creek, east of and across highway from Union Oil Company storage plant, in walk.
190.724	About 1.15 miles south of Portland city limit, 86 feet south of King Road, 22 feet east of SE 82nd Ave. Disk in concrete post under box set in pavement.
188.684	About 1.2 miles south of Portland city limit, 2.65 miles north from Clackamas, 210 feet south of King Road, 32 feet west of SE 82nd Ave., in service station gasoline pump base.
156.834	About 1.9 miles north of Clackamas, 625 feet north of center of Sunnyside Road, southeast corner of skew culvert under SE 82nd Ave., top of parapet.
153.936	About 1.7 miles north of Clackamas, 35 feet north of Sunnyside Road, 85 feet north of service station, 25 feet east of 82nd Ave. Disk in concrete post in box set in pavement.
123.960	About 1.3 miles north of Clackamas, 16 feet east of centerline of 82nd Ave., in the northeast corner of concrete viaduct over Southern Pacific Company's tracks. Disk in concrete walk.
96.427	About 1.2 miles north of Clackamas, 380 feet south of crossing of Southern Pacific Comapny's tracks and SE 82nd Ave., 100 feet northwest of service station, 20 feet west of avenue, southwest corner of culvert, top of parapet.

151.437	South part of Clackamas, 143 feet south of road east to Carver, 126 feet south of road west to Milwaukie, 28 feet east of highway. Disk in concrete post.
113.005	410 feet north of Southern Pacific Company station, 14 feet west of main track, 20 feet south of Clackamas-Carver road, southwest corner of concrete base for retaining wall.
130.470	About 1.6 miles east of Clackamas on Clackamas Secondary Highway, 29 feet southerly from the highway centerline, 38 feet east of centerline of road to East Clackamas School. Disk in concrete monument.
169.375	About 1.2 miles west of Carver on Clackamas Secondary Highway, 3.12 miles east of Clackamas, in curb at northwest corner of Rock Crddk bridge.
298.969	About 1.3 miles north of Clackamas, 3.4 miles east of Carver, 2.5 miles west of Damascus, 290 feet east of southeast corner of Smalley house, 172 feet northeast of large forked fir tree, 9 feet north of road centerline.

APPENDIX IV

Program GRAVREDUC.

Written for the PSU Harris 220 computer by the author.

Last revision 3-23-77.

Reference for gravity reduction formulas; Dobrin (1976).

This program performs most of the basic gravity reduction calculations, after drift and instrument corrections have been made. It calculates the theoretical gravity, Bouguer correction, free air correction, free air anomaly, simple Bouguer anomaly, and the complete Bouguer anomaly, all in milligals. It also converts the elevation of the station occupied from feet to meters. One data card is used for each station. Each data card contains the station number, elevation in feet, terrain correction in milligals, latitude in degrees, and the measured absolute gravity in milligals. Double precision must be used due to the large number of significant digits in the theoretical and observed gravity. A sample printout of this program with the data used in this thesis is included in the pocket.

INPUT RECORD

First card in data deck; COMNT-comment card-Format 20A4.
Each following card contains-

NSTAT	Station number
ELEV	Elevation in feet
TERCR	Terrain correction in milligals
DLAT	Latitude in degrees
ABSLG	Measured gravity in milligals
DLONG	Longitude in degrees

Format (I10,2F10.4,F10.6,F20.4,10X,F10.0)

APPENDIX V

Program GRAVPLOT.

Written for the PSU Harris 220 computer by the author.

Last revision 3-23-77.

Reference for PLTR subroutine; Davis (1973).

This program performs the data reduction indentically to program GRAVREDUC. In addition, it contains subroutine PLTR1 which plots the gravity and elevation profiles for rapid comparison and error checks. Double precision is again used.

The only difference in the input record is that the second card in the data deck of GRAVPLOT contains LINEN, which is the total number of lines to be printed each time subroutine PLTR1 is called. LINEN thus controls the length of the plotted profile. Its format is I5. In addition each data card contains HDIST, the distance from the west end of the line in kilometers (Format F10.0) replacing the 10X in program GRAVREDUC.

GRAVPLOT establishes arrays containing the Bouguer anomaly, elevation, and free air anomaly, and plots them against the horizontal distance along the ground.

Subroutine PLTR1

This program plots two sets of two-dimensional arrays, X1 and X2 containing N1 and N2 number of rows. If only one array is desired to be plotted, one of the arrays may be assigned to zero. The subroutine searches through each of the arrays for the largest and smallest value of each variable and on this basis establishes a grid which gives the maximum scale for the data.

APPENDIX VI

Program BOUGUERFIT

Adapted from the Oregon State Computer system to the PSU Harris 220 computer by A.G. Johnson.

Last revision 3-23-77.

Original algorithm by Talwani et al. (1959).

This program computes the vertical component of the gravitational attraction caused by two-dimensional bodies at various field points. The user must specify the interval and place of origin for the computed points and the program calculates the anomaly across the top of the rectangle at Z=0 at the specified interval. The areas of different densities within the model are approximated by polygons, and the vertical attraction is computed using the line integral technique with the formulas derived by Talwani et al. (1959).

The topography may not be included along the top of the rectangle, thus the computed anomaly corresponds to the Bouguer anomaly. All distances are in kilometers with Z positive downwards. The rectangle is ordinarily extended about 100 kilometers or more on either side of the area of interest in order to eliminate edge effects. A larger distance may be required if the rectangle is made much deeper than five kilometers. The model check (TIT) is used to locate errors within the model. If there are no holes or overlapping blocks in the model TIT will be small and symmetrical around the center of the block with no discontinuities. Any errors in the block will be located below discontinuities in TIT.

The number of blocks in the model (N), number of computed points (M), and the number of corners to each block (J), are limited only by the size of the core of the computer. This program is dimensioned to accept up to 900 computed points and 900 corners in each block, but these numbers may be increased as needed.

The top of the model is ordinarily made to coincide with sea level and must be flat to correlate with the Bouguer anomaly.

This program can also make corrections for a regional gradient which changes at one location across the line. GRAD1 is the first regional gradient. GRAD2 is the second regional gradient, and GRADS is the location along the top of the rectangle where the gradient changes from GRAD1 to GRAD2. If only one regional gradient is encountered across the line assign GRAD2 to the same value as GRAD1. GRADS may then have any reasonable value and will not affect the results. If no regional correction is desired assign GRAD1, GRAD2, and GRADS to 0.

The coordinate system normally has its origin at the upper left corner of the rectangle. The block corners must be given with the upper left corner first, proceeding clockwise around the block. INN is assigned the number of models to be calculated per computer run in order to terminate the program. TOT(I) represents the computed gravity anomaly in milligals.

INPUT RECORD

First card-used once per model.

SAM1,SAM2	Cross section number.
PX(I)	First location where gravity is to be computed.
STEP	Interval between computed points.
M	Number of computed points.
N	Number of blocks.

Format (2A4,F6.0,F4.0,2I5)

Second card-used once per model.

GRAD1,GRAD2,GRADS	Regional Gradients.

Format (3F10.0)

Series of N cards-

RHO	Block density.
J	Number of corners in block.
ISALT	Block number.

Format (F5.0,I3,6X,I2)

Followed by a series of J cards each containing X and Z coordinates of block corners.

X(I)	X coordinate.
Z(I)	Z coordinate

Format (10F8.0)

The last card contains the X and Z coordinates of the corners of the total rectangle.

Format (10F8.0)

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STOP
END
EOF..                                                                                                          pt.1/1
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**                       J   J    D    D    ..     J   J    0    0    N  N  N   EEEE          S                       **  203
**                       J   J    D    D    ..     J   J    0    0    N   NN   E        S     S                       **  203
**                        JJJ     DDDDD             JJJ      0000     N     N   EEEEEE    SSSS                        **  203
**                                                                                                                   **  203
**                                                                                                                   **  203
**                                                                                                                   **  203
**                                                                                                                   **  203
***********************************************************************************************************************  203
JOB,GRAVREDUC,5013A001,JD.JONES                                                     7 JUN 77 13:41:50
===> $$*FORTRAN
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```
      FRAA=ABSLG+FRAC-THGRV
      SBGAN=FRAA-BGC
      CBGAN=SBGAN+TERCR
      ELEV1=ELEV*0.3048
      WRITE (5,100) NSTAT, ELEV1,DLONG, DLAT, TERCR, ABSLG, THGRV, BGC,
     1FRAC, FRAA, SBGAN, CBGAN
100   FORMAT (' ', I4, F10.2, F11.4, F11.5, F7.3, F16.3, F11.3, F8.3,
     1F8.3, F10.3, F9.3, F10.3)
      GO TO 10
999   CALL EXIT
      END
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pT 1/4

OAK GROVE GRAVITY LINE 4-7-76 DATA BY T JONES AND Z MOORE

STATION NUMBER	ELEVATION METERS	LONGITUDE DEGREES	LATTITUDE DEGREES	TERRAIN CORREC. MGALS	OBSERVED GRAVITY MGALS	THEORITICAL GRAVITY MGALS	BOUGUER CORREC. MGALS	FREE AIR CORREC. MGALS	FREE AIR ANOMALY MGALS	SIMPLE BOUGUER ANOMALY MGALS	COMPLETE BOUGUER ANOMALY MGALS
308	35.05	122.8625	45.25731	.300	980611.640	980652.547	3.918	10.817	-30.090	-34.008	-33.708
307	32.61	122.8477	45.26545	.300	980612.860	980653.282	3.645	10.064	-30.357	-34.003	-33.703
306	48.77	122.8287	45.28243	.220	980614.100	980654.814	5.451	15.050	-25.665	-31.116	-30.896
305	51.21	122.8157	45.29002	.110	980614.730	980655.500	5.724	15.802	-24.967	-30.691	-30.581
304	44.81	122.7785	45.30309	.040	980615.940	980656.679	5.008	13.827	-26.913	-31.921	-31.881
303	81.69	122.7427	45.33207	.080	980619.900	980659.295	9.130	25.208	-14.187	-23.318	-23.238
302	125.88	122.7212	45.35738	.110	980613.760	980661.580	14.070	38.847	-8.973	-23.044	-22.934
301	112.78	122.7076	45.36688	.700	980622.820	980662.458	12.606	34.802	-4.816	-17.421	-16.721
258	50.90	122.6802	45.35837	.400	980633.600	980661.670	5.690	15.708	-12.362	-18.051	-17.651
257	48.77	122.6780	45.35913	.420	980635.070	980661.738	5.451	15.050	-11.619	-17.070	-16.650
256	51.82	122.6761	45.36084	.440	980635.910	980661.893	5.792	15.990	-9.992	-15.784	-15.344
255	53.34	122.6742	45.36100	.460	980634.800	980661.907	5.962	16.460	-10.646	-16.609	-16.149
254	38.71	122.6699	45.36084	.490	980640.300	980661.893	4.327	11.946	-9.647	-13.974	-13.484
253	38.10	122.6667	45.36100	.510	980639.670	980661.907	4.259	11.757	-10.479	-14.738	-14.228
252	59.74	122.6648	45.36248	.540	980636.850	980662.041	6.678	18.436	-6.755	-13.432	-12.892
251	67.36	122.6636	45.36342	.560	980636.550	980662.125	7.529	20.787	-4.788	-12.317	-11.757
250	68.28	122.6688	45.36462	.590	980636.190	980662.234	7.631	21.069	-4.974	-12.606	-12.016
249	82.60	122.6699	45.36561	.620	980632.570	980662.323	9.233	25.490	-4.263	-13.496	-12.876
248	94.49	122.6699	45.36638	.650	980629.790	980662.393	10.561	29.159	-3.444	-14.005	-13.355
247	107.29	122.6699	45.36891	.670	980627.650	980662.621	11.992	33.109	-1.862	-13.854	-13.184
246	123.75	122.6693	45.37000	.700	980624.270	980662.719	13.832	38.188	-.261	-14.093	-13.393
245	131.67	122.6678	45.37044	.720	980623.290	980662.759	14.718	40.634	1.165	-13.553	-12.833
244	125.88	122.6667	45.37171	.720	980624.850	980662.874	14.070	38.847	.823	-13.247	-12.527
243	134.11	122.6650	45.37209	.710	980623.550	980662.908	14.990	41.386	2.028	-12.962	-12.252
242	144.48	122.6636	45.37280	.700	980621.630	980662.972	16.149	44.584	3.242	-12.906	-12.206
241	153.92	122.6609	45.37182	.690	980619.740	980662.884	17.205	47.500	4.357	-12.848	-12.158
240	170.08	122.6594	45.37352	.680	980616.470	980663.037	19.011	52.485	5.918	-13.092	-12.412
239	171.30	122.6580	45.37407	.670	980616.140	980663.087	19.147	52.862	5.915	-13.232	-12.562
238	182.88	122.6569	45.37462	.660	980615.760	980663.136	20.441	56.436	9.060	-11.382	-10.722
237	191.41	122.6559	45.37549	.650	980612.450	980663.215	21.395	59.070	8.305	-13.091	-12.441
236	201.78	122.6548	45.37648	.640	980609.900	980663.304	22.554	62.268	8.863	-13.690	-13.050
235	215.19	122.6575	45.38015	.710	980607.180	980663.636	24.053	66.406	9.951	-14.102	-13.392
234	211.53	122.6570	45.38103	.780	980608.060	980663.715	23.644	65.278	9.623	-14.021	-13.241
233	210.92	122.6575	45.38224	.850	980608.220	980663.824	23.576	65.090	9.485	-14.091	-13.241
232	204.52	122.6552	45.38246	.930	980609.790	980663.844	22.860	63.114	9.060	-13.800	-12.870
231	207.87	122.6550	45.38388	1.000	980608.760	980663.972	23.235	64.149	8.937	-14.299	-13.299
230	205.28	122.6550	45.38553	1.070	980608.990	980664.121	22.945	63.349	8.218	-14.727	-13.657
229	200.86	122.6554	45.38664	1.140	980609.730	980664.240	22.451	61.986	7.476	-14.975	-13.835
228	195.07	122.6547	45.38755	1.210	980610.690	980664.304	21.804	60.198	6.585	-15.219	-14.009
227	189.59	122.6536	45.38755	1.170	980611.640	980664.304	21.191	58.505	6.042	-15.149	-13.979
226	179.83	122.6513	45.38761	1.120	980613.820	980664.309	20.101	55.495	5.006	-15.094	-13.974
225	164.59	122.6526	45.38997	1.080	980617.160	980664.522	18.397	50.792	3.430	-14.967	-13.887
224	149.96	122.6517	45.39062	1.030	980619.940	980664.581	16.762	46.278	1.637	-15.125	-14.095
223	134.72	122.6507	45.39041	.990	980623.210	980664.562	15.058	41.575	.223	-14.836	-13.846
222	115.21	122.6496	45.38969	.940	980626.550	980664.497	12.878	35.555	-2.392	-15.270	-14.330
221	103.63	122.6491	45.39024	.900	980628.810	980664.546	11.583	31.980	-3.756	-15.340	-14.440
220	94.34	122.6486	45.39051	.860	980630.860	980664.571	10.544	29.112	-4.599	-15.144	-14.284
219	80.16	122.6478	45.39079	.820	980633.840	980664.596	8.960	24.738	-6.018	-14.978	-14.158
218	66.14	122.6467	45.39106	.770	980636.930	980664.621	7.393	20.411	-7.280	-14.673	-13.903
217	60.96	122.6459	45.39139	.730	980637.990	980664.650	6.814	18.812	-7.848	-14.662	-13.932
216	53.74	122.6454	45.39189	.680	980639.750	980664.695	6.006	16.583	-8.363	-14.369	-13.689
215	54.25	122.6439	45.39073	.640	980639.750	980664.591	6.064	16.743	-8.098	-14.162	-13.522
214	45.72	122.6424	45.39106	.630	980641.590	980664.620	5.110	14.109	-8.922	-14.032	-13.402
213	40.84	122.6412	45.39120	.610	980642.730	980664.640	4.565	12.604	-9.306	-13.872	-13.262
212	38.37	122.6003	45.39194	.590	980643.360	980664.700	4.289	11.842	-9.498	-13.787	-13.197
211	36.58	122.6394	45.39232	.570	980643.680	980664.734	4.088	11.287	-9.767	-13.855	-13.285
210	35.36	122.6388	45.39205	.560	980643.900	980664.710	3.952	10.911	-9.899	-13.851	-13.291

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209	53.83	122.6372	45.39172	.550	980644.130	980664.680	3.782	10.441	-10.109	-13.891	-13.341
208	26.82	122.6363	45.39106	.530	980645.720	980664.620	2.998	8.277	-10.623	-13.621	-13.091
207	36.68	122.6347	45.39084	.510	980643.390	980664.601	4.122	11.381	-9.829	-13.952	-13.442
206	37.80	122.6331	45.39030	.500	980642.970	980664.552	4.225	11.663	-9.918	-14.143	-13.643
205	34.59	122.6366	45.39331	.490	980644.010	980664.824	3.867	10.676	-10.138	-14.005	-13.515
204	22.80	122.6358	45.39408	.480	980644.710	980664.693	2.548	7.036	-13.147	-15.696	-15.216
203	20.45	122.6343	45.39457	.460	980647.540	980664.937	2.286	6.311	-11.086	-13.372	-12.912
202	11.73	122.6326	45.39397	.450	980648.960	980664.883	1.312	3.621	-12.282	-13.593	-13.143
201	2.74	122.6317	45.39380	.430	980650.960	980664.868	.307	.847	-13.041	-13.348	-12.918
69	2.46	122.6333	45.39717	.430	980651.420	980665.172	.278	.767	-12.985	-13.263	-12.833
68	12.45	122.6325	45.39811	.420	980649.360	980665.257	1.392	3.842	-12.055	-13.446	-13.026
67	17.39	122.6316	45.39865	.400	980648.440	980665.306	1.944	5.366	-11.500	-13.443	-13.043
66	16.82	122.6310	45.39898	.370	980648.570	980665.335	1.880	5.189	-11.576	-13.456	-13.086
65	23.48	122.6302	45.39958	.340	980647.320	980665.390	2.624	7.245	-10.825	-13.449	-13.109
62	28.78	122.6276	45.39794	.310	980646.030	980665.242	3.216	8.880	-10.331	-13.548	-13.238
61	23.86	122.6265	45.39860	.270	980647.440	980665.301	2.667	7.362	-10.499	-13.166	-12.896
60	19.14	122.6255	45.39887	.240	980648.620	980665.325	2.140	5.908	-10.798	-12.937	-12.697
59	20.58	122.6245	45.39936	.200	980648.450	980665.370	2.301	6.352	-10.568	-12.869	-12.669
58	20.36	122.6236	45.39980	.200	980648.090	980665.409	2.275	6.282	-11.037	-13.313	-13.113
57	21.56	122.6227	45.40030	.210	980647.620	980665.455	2.412	6.659	-11.176	-13.588	-13.378
56	24.43	122.6217	45.40112	.220	980647.120	980665.529	2.730	7.538	-10.871	-13.601	-13.381
55	30.07	122.6210	45.40123	.230	980645.900	980665.539	3.361	9.279	-10.360	-13.720	-13.490
54	34.29	122.6200	45.40166	.240	980645.100	980665.577	3.833	10.582	-9.896	-13.728	-13.488
53	36.90	122.6191	45.40227	.250	980644.760	980665.632	4.124	11.386	-9.486	-13.611	-13.361
52	39.55	122.6180	45.40287	.260	980644.420	980665.687	4.421	12.206	-9.060	-13.482	-13.222
51	45.70	122.6164	45.40364	.270	980643.040	980665.756	5.109	14.104	-8.612	-13.720	-13.450
50	55.26	122.6157	45.40390	.280	980641.410	980665.785	6.176	17.052	-7.323	-13.499	-13.219
49	59.99	122.6154	45.40429	.280	980640.320	980665.815	6.705	18.512	-6.983	-13.688	-13.408
48	64.94	122.6145	45.40473	.260	980639.270	980665.854	7.259	20.041	-6.543	-13.802	-13.522
47	71.26	122.6139	45.40517	.270	980637.790	980665.894	7.965	21.989	-6.115	-14.080	-13.810
46	79.62	122.6133	45.40566	.260	980635.930	980665.938	8.900	24.571	-5.437	-14.337	-14.077
44	87.68	122.6134	45.40654	.250	980634.130	980666.018	9.801	27.058	-4.830	-14.630	-14.380
43	97.57	122.6125	45.40708	.260	980631.940	980666.067	10.906	30.110	-4.016	-14.922	-14.662
42	100.40	122.6114	45.40774	.270	980631.540	980666.126	11.222	30.981	-3.605	-14.826	-14.556
41	103.48	122.6104	45.40845	.270	980630.890	980666.190	11.566	31.932	-3.368	-14.934	-14.664
40	106.53	122.6098	45.40800	.280	980630.410	980666.150	11.908	32.876	-2.864	-14.772	-14.492
39	107.87	122.6085	45.40966	.280	980630.200	980666.300	12.057	33.288	-2.812	-14.869	-14.589
38	106.34	122.6076	45.40917	.280	980630.660	980666.255	11.886	32.815	-2.761	-14.646	-14.366
37	104.64	122.6068	45.40993	.290	980630.800	980666.324	11.697	32.293	-3.231	-14.928	-14.638
36	99.15	122.6057	45.41059	.300	980631.550	980666.383	11.082	30.597	-4.237	-15.319	-15.019
35	95.63	122.6049	45.41114	.310	980632.420	980666.433	10.689	29.511	-4.502	-15.191	-14.881
34	90.72	122.6044	45.41157	.320	980633.360	980666.472	10.140	27.995	-5.117	-15.257	-14.937
33	86.45	122.6038	45.41212	.330	980634.230	980666.522	9.663	26.679	-5.612	-15.276	-14.946
32	81.67	122.6031	45.41261	.340	980634.670	980666.566	9.128	25.202	-6.693	-15.822	-15.482
31	79.04	122.6025	45.41294	.350	980634.950	980666.596	8.835	24.392	-7.254	-16.089	-15.739
30	68.63	122.6018	45.41349	.350	980637.110	980666.645	7.672	21.180	-8.355	-16.026	-15.676
29	57.54	122.6011	45.41398	.350	980638.910	980666.689	6.431	17.756	-10.024	-16.455	-16.105
28	48.40	122.6004	45.41453	.320	980640.340	980666.739	5.410	14.936	-11.463	-16.873	-16.553
27	43.18	122.5997	45.41508	.290	980640.890	980666.789	4.826	13.325	-12.574	-17.400	-17.110
26	32.10	122.5997	45.41623	.270	980642.880	980666.893	3.588	9.905	-14.107	-17.695	-17.425
25	26.55	122.5983	45.41623	.250	980642.390	980666.893	2.968	8.194	-16.309	-19.277	-19.027
24	26.14	122.5972	45.41617	.230	980641.600	980666.887	2.928	8.084	-17.124	-20.052	-19.822
23	29.39	122.5961	45.41617	.200	980640.590	980666.887	3.285	9.069	-17.228	-20.513	-20.313
22	30.20	122.5951	45.41612	.180	980640.460	980666.883	3.376	9.319	-17.103	-20.479	-20.299
21	33.95	122.5940	45.41612	.150	980639.270	980666.883	3.794	10.475	-17.137	-20.931	-20.781
20	40.46	122.5931	45.41612	.130	980637.410	980666.883	4.522	12.486	-16.987	-21.509	-21.379
19	47.00	122.5917	45.41606	.110	980635.760	980666.877	5.253	14.504	-16.613	-21.867	-21.757
18	46.95	122.5922	45.41743	.110	980635.580	980667.001	5.248	14.490	-16.931	-22.179	-22.069
16	44.44	122.5922	45.41946	.110	980635.840	980667.184	4.968	13.715	-17.629	-22.597	-22.487
14	35.35	122.5922	45.42182	.100	980637.790	980667.397	3.952	10.910	-18.697	-22.649	-22.549
12	32.03	122.5922	45.42376	.100	980638.370	980667.572	3.580	9.885	-19.310	-22.898	-22.798
10	34.42	122.5890	45.42325	.100	980637.810	980667.526	3.847	10.622	-19.094	-22.941	-22.841
8	33.64	122.5866	45.42314	.100	980637.930	980667.516	3.760	10.380	-19.206	-22.966	-22.866
6	37.64	122.5838	45.42297	.110	980637.030	980667.501	4.207	11.615	-18.856	-23.063	-22.953
4	39.65	122.5805	45.42155	.120	980637.160	980667.373	4.432	12.237	-17.976	-22.408	-22.288
2	38.18	122.5777	45.42204	.130	980638.040	980667.417	4.267	11.782	-17.595	-21.863	-21.733

pt. 1/6

1	[illegible]	[illegible]	[illegible]	.130	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
101	37.76	122.5756	45.42675	.200	980637.940	980667.442	4.223	11.660	-18.243	-22.466	-22.266
102	98.17	122.5526	45.43690	.340	980627.840	980668.758	9.855	27.208	-13.661	-23.515	-23.175
103	169.94	122.5567	45.44578	1.020	980609.840	980669.560	18.995	52.442	-7.273	-26.273	-25.253
104	203.32	122.5470	45.46129	.650	980602.700	980670.960	22.726	62.743	-5.517	-28.243	-27.593
105	141.22	122.5311	45.46946	.540	980611.440	980671.096	14.067	40.494	-17.214	-31.881	-31.341
106	43.82	122.5030	45.47888	.490	980620.760	980672.408	4.324	29.188	-29.881	-39.188	-38.848
108	74.41	122.5081	45.49243	.650	980620.030	980673.771	8.324	22.983	-30.758	-39.083	-38.433
107	74.91	122.4996	45.50461	.060	980620.190	980674.870	8.380	23.136	-31.544	-39.924	-39.864
109	76.22	122.4761	45.52261	.050	980618.330	980676.495	8.519	23.521	-34.645	-43.164	-43.114
110	62.59	122.4662	45.53406	.080	980621.960	980677.529	6.996	19.314	-36.254	-43.250	-43.170
111	25.23	122.4587	45.54528	.130	980631.790	980678.541	2.820	7.785	-38.966	-41.786	-41.656

PT 2/1

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***********************    PORTLAND STATE UNIVERSITY - COMPUTING SERVICES CENTER  HARRIS / 220    **********************    384
**                                                                                                                    **    384
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**                           JO.JONES                    27 MAY 77 18:16:05                                           **    384
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**                            JOB: 007746                                                                             **    384
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**                                                                                                                    **    384
**                    JJJJJJ   DDDDD             JJJJJJ    OOOO    N     N  EEEEEE    SSSS                            **    384
**                        J    D    D                J    O    O   NN    N  E        S                                **    384
**                        J    D    D                J    O    O   N N   N  E         SSSS                            **    384
**                    J   J    D    D    ..      J   J    O    O   N  N  N  EEEE          S                           **    384
**                    J   J    D    D    ..      J   J    O    O   N   NN   E        S    S                           **    384
**                     JJJ     DDDDD              JJJ      OOOO    N     N  EEEEEE    SSSS                            **    384
**                                                                                                                    **    384
**                                                                                                                    **    384
**                                                                                                                    **    384
**                                                                                                                    **    384
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JOB,GRAVPLOT,5013A001,JO.JONESL#20000,T#200                                         27 MAY 77 18:11:34
====> $$*FORTRAN
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C     PROGRAM 5.4 (P.211)
C     THIS PROGRAM CALCULATES THE THEORITICAL GRAVITY, BOUGUER CORRECTION,
C     FREE AIR CORRECTION, FREE AIR ANOMALY, SIMPLE BOUGUER ANOMALY, AND
C     THE COMPLETE BOUGUER ANOMALY, ALL IN MILLIGALS.  IT ALSO CONVERTS THE
C     ELEVATION OF THE STATION OCCUPIED FROM FEET TO METERS.  ONE DATA
C     CARD IS USED FOR EACH STATION.  EACH DATA CARD CONTAINS THE STATION
C     NUMBER, ELLEVATION IN FEET, TERRAIN CORRECTION IN MILLIGALS, LATTITUDE
C     IN DEGREES, AND THE MEASURED ABSOLUTE GRAVITY IN MILLIGALS.
C
C
C     SUBROUTINE PLTR1 PLOTS GRAVITY AND ELEVATION PROFILES WITH THE
C     DISTANCE BETWEEN THE PROJECTIONS OF FIELD STATIONS ON A STRAIGHT
C     LINE ALONG THE VERTICLE AXIS
C
C
C
C                                EXPLANATION
C
C             DATA CARD SYMBOLS                                       FORMAT
C
C       COMNT   COMMENT CARD
C       LINEN   NUMBER OF LINES TO BE PRINTED BY SUBROUTINE PLTR        20A4
C       NSTAT   STATION NUMBER                                          I5
C       ELEV    ELEVATION IN FEET                                       I10
C       TERCR   TERRAIN CORRECTION IN MILLIGALS                         F10.
C       DLAT    LATTITUDE IN DEGREES                                    F10.4
C       ABSLG   MEASURED ABSOLUTE GRAVITY IN MILLIGALS                  F10.6
C       HDIST   HORIZONTAL DISTANCE FROM INITIAL POINT IN METERS        F20.4
C                                                                       F16.2
C
C                           PROGRAM SYMBOLS
C
C       RLAT    LATTITUDE IN DEGREES
C       THGRV   THEORITICAL GRAVITY IN MILLIGALS
C       FRAC    FREE AIR CORRECTION IN MILLIGALS
C       BGC     BOUGUER CORRECTION IN MILLIGALS
C       FRAA    FREE AIR ANOMALY IN MILLIGALS
C       SBGAN   SIMPLE BOUGUER ANOMALY IN MILLIGALS
C       CBGAN   COMPLETE BOUGUER ANOMALY IN MILLIGALS
C       ELEV1   ELEVATION IN METERS
C       GRV-    ARRAY CONTAINING FRAA, ELEV1, ELEV2, CBGAN FOR PLTR1
C
C
      DIMENSION COMNT(20)
      DOUBLE PRECISION ELEV,TERCR,DLAT,ABSLG,HDIST,RLAT,THGRV,FRAC,BGC,
     1FRAA,SBGAN,CBGAN,ELEV1,GRVF(150,2),GRVB(150,2),GRVE(150,2)
     2,GRVX(150,2),GRVD(150,2)
C
C...INPUT DATA AND PRINT TABLE HEADINGS
C
      READ (2,2) (COMNT(I),I=1,20)
    2 FORMAT (20A4)
      WRITE (5,3) (COMNT(I),I=1,20)
    3 FORMAT ('1',20A4)
      READ (2,11) LINEN
   11 FORMAT (I5)
      WRITE (5,12) LINEN
   12 FORMAT (' ',I10,' LINES TO BE PRINTED BY SUBROUTINE PLTR1')
```

```
      WRITE (5,4)
4     FORMAT ('0','STATION ELEVATION ELEVATION LATTITUDE TERRAIN    OBSE
     1RVED   THEORITICAL BOUGUER FREE AIR FREE AIR SIMPLE     COMPLETE')
      WRITE (5,5)
5     FORMAT (' ', 'NUMBER  FEET      METERS    DEGREES  CORREC.    GRA
     1VITY    GRAVITY     CORREC. CORREC.  ANOMALY  BOUGUER   BOUGUER')
      WRITE (5,6)
6     FORMAT (' ', 38X, 'MGALS       MGALS       MGALS       MGALS   MGALS
     1     MGALS     ANOMALY   ANOMALY')
      WRITE (5,8)
      I=0
8     FORMAT (' ', 98X, 'MGALS     MGALS')
10    READ (2,50) NSTAT, ELEV, TERCR, DLAT, ABSLG,HDIST
50    FORMAT (I10, 2F10.4, F10.6, F20.4,F10.4)
      IF (NSTAT) 999,999,55
C
C...REDUCTION OF GRAVITY DATA
C
55    RLAT=DLAT*0.017453
      THGRV=978049.0*((1.0+0.0052884*(DSIN(RLAT))**2)
     1-(0.0000059*(SIN(2.0*RLAT))**2))
      FRAC=0.09406*ELEV
      BGC=0.034069*ELEV
      FRAA=ABSLG+FRAC-THGRV
      SBGAN=FRAA-BGC
      CBGAN=SBGAN+TERCR
      ELEV1=ELEV*0.3048
      ELEV2=(ELEV1/10)-40
      WRITE (5,100) NSTAT, ELEV, ELEV1, DLAT, TERCR, ABSLG, THGRV, BGC,
     1FRAC, FRAA, SBGAN, CBGAN
100   FORMAT (' ', I4, F11.2, F10.2, F11.5, F7.3, F16.3, F11.3, F8.3,
     1F8.3, F10.3, F9.3, F10.3)
      I=I+1
      IXXX=0
C
C...ESTABLISH ARRAYS FOR PLOTTER SUBROUTINE
C
      GRVX(I,1)=0.
      GRVX(I,2)=0.
      GRVD(I,1)=ELEV2
      GRVD(I,2)=HDIST
      GRVF(I,1)=FRAA
      GRVF(I,2)=HDIST
      GRVB(I,1)=CBGAN
      GRVB(I,2)=HDIST
      GRVE(I,1)=ELEV1
      GRVE(I,2)=HDIST
      GO TO 10
999   WRITE (5,9)
9     FORMAT('1',3X,'HDIST',5X,'FRAA',5X,'CBGAN',5X,'ELEV1',5X,'ELEV2')
      DO 39 K=1,I
39    WRITE (5,7)GRVF(K,2),GRVF(K,1),GRVB(K,1),GRVE(K,1),GRVD(K,1)
7     FORMAT(' ',F10.0,4F10.2)
C
C...PLOT GRAVITY PROFILES
C
      WRITE (5,401)
```

```
801   FORMAT ('1',' BOUGUER ANOMALY=*     ELEVATION=X
     1      REGIONAL GRAVITY PROFILE')
      CALL PLTR1 (GRVB,I,GRVO,I,LINEN)
      WRITE (5,802)
802   FORMAT ('1', 'ELEVATION=*        FREE AIR ANOMALY=X
     1         REGIONAL GRAVITY PROFILE')
      CALL PLTR1 (GRVO,I,GRVF,I,LINEN)
      WRITE (5,803)
803   FORMAT ('1', 'BOUGUER ANOMALY=*           FREE AIR ANOMALY=X
     1      REGIONAL GRAVITY PROFILE')
      CALL PLTR1 (GRVB,I,GRVF,I,LINEN)
      WRITE (5,806)
806   FORMAT ('1', 'ELEVATION-REGIONAL')
      CALL PLTR1 (GRVE,I,GRVX,IXXX,LINEN)
      WRITE (5,805)
805   FORMAT ('1',' FREE AIR ANOMALY-REGIONAL')
      CALL PLTR1 (GRVF,I,GRVX,IXXX,LINEN)
      WRITE (5,804)
804   FORMAT ('1',' BOUGUER ANOMALY-REGIONAL')
      CALL PLTR1 (GRVB,I,GRVX,IXXX,LINEN)
      CALL EXIT
      END
```

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```
C
C   X1 CONTAINS THE FIRST SET OF VARIABLES TO BE PLOTTED
C   X1(I,1) IS A VARIABLE PLOTTED IN THE X DIRECTION
C   X1(I,2) IS THE ITH VARIABLE PLOTTED IN THE Y DIRECTION
C   X2 CONTAINS A SECOND SET OF VARIABLES TO BE PLOTTED
C   N1 IS THE ACTUAL NUMBER OF ROWS IN THE ARRAY X1
C   N2 IS THE ACTUAL NUMBER OF ROWS IN X2
C   NLINE IS THE NUMBER OF HORIZONTAL LINES TO BE PRINTED BY THE PLOTTER
C========================================================================
C
      SUBROUTINE PLTR1(X1,N1,X2,N2,NLINE)
      DIMENSION X1(150,2),X2(150,2),IOUT(101),XX(11)
      DATA IBLNK,II,IPLUS,IXI,MINUS,ISTAR,IO/' ','I','+','X','-','*','0'
     1/
C
C... FIND MIN-MAX OF DATA
C
      XMIN=X1(1,1)
      XMAX=XMIN
      YMIN=X1(1,2)
      YMAX=YMIN
      DO 100 I=1,N1
      IF(X1(I,1)-XMIN)20,21,21
20    XMIN=X1(I,1)
21    IF(X1(I,1)-XMAX)23,23,22
22    XMAX=X1(I,1)
23    IF(X1(I,2)-YMIN)24,25,25
24    YMIN=X1(I,2)
25    IF(X1(I,2)-YMAX)100,100,26
26    YMAX=X1(I,2)
100   CONTINUE
      IF (N2)1,1,27
27    DO 101 I=1,N2
      IF(X2(I,1)-XMIN)28,29,29
28    XMIN=X2(I,1)
29    IF(X2(I,1)-XMAX)31,31,30
30    XMAX=X2(I,1)
31    IF(X2(I,2)-YMIN)32,33,33
32    YMIN=X2(I,2)
33    IF(X2(I,2)-YMAX)101,101,34
34    YMAX=X2(I,2)
101   CONTINUE
C
C...ESTABLISH GRID INTERVAL FOR DATA
C
1     DX=(XMAX-XMIN)/100.
      DY=(YMAX-YMIN)/NLINE
C
      WRITE(5,1000)
C
C   SUPPRESS PRINTING SO THAT GRAPH WILL BE PRINTED ON ONE PAGE
C
      WRITE(5,1005)
C
C
C...GENERATE COORDINATE SYSTEM
C
```

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```
      Y=YMAX
      JX=NLINE+1
      DO 102 I=1,JX
      IF(MOD(I-1,6))35,2,35
35    DO 103 J=1,101
      IOUT(J)=IPLEY
      IF(MOD(J-1,10))103,36,103
36    IOUT(J)=II
103   CONTINUE
      GO TO 3
2     DO 104 J=1,101
      IOUT(J)=LINUS
      IF(MOD(J-1,10))104,37,104
37    IOUT(J)=IPLUS
104   CONTINUE
C
C...PLOT DATA SET ONE
C
3     DO 105 J=1,N1
      IY=IFIX((X1(J,2)-YMIN)/DY+0.005)+1
      IF(I-IY)105,38,105
38    IX=IFIX((X1(J,1)-XMIN)/DX+0.005)+1
      IOUT(IX)=ISTAR
105   CONTINUE
C
C...PLOT DATA SET TWO
C
      IF(N2)10,10,39
39    DO 106 J=1,N2
      IY=IFIX((X2(J,2)-YMIN)/DY+0.005)+1
      IF (I-IY)106,40,106
40    IX=IFIX((X2(J,1)-XMIN)/DX+0.005)+1
      IF(IX-100)42,42,41
41    IX=100
42    IF(IOUT(IX)-ISTAR)44,4,44
44    IOUT(IX)=IXI
      GO TO 106
4     IOUT(IX)=IO
106   CONTINUE
C
C...PRINT LINE OF PLOT
C
10    IF(MOD(I-1,6))11,45,11
45    WRITE(5,1001)Y,IOUT
      Y=Y-6.0*DY
      GO TO 102
11    WRITE(5,1002)IOUT
102   CONTINUE
C...PRINT LEGEND ACROSS BOTTOM OF GRAPH
C
      XXX=XMIN
      DO 110 I=1,11
      XX(I)=XXX
      XXX=XXX+10.0*DX
110   CONTINUE
      WRITE (5,1003) (XX(I),I=1,11,2)
      WRITE(5,1004)(XX(I),I=2,10,2)
```

```
C
C   RESTORE NORMAL PRINTING
C
      WRITE(5,1006)
      RETURN
 1000 FORMAT (1H )
 1001 FORMAT(1H ,F10.0,1X,101A1)
 1002 FORMAT(1H ,11X,101A1)
 1003 FORMAT(8X,F10.3,5(10X,F10.3))
 1004 FORMAT(18X,5(F10.3,10X))
 1005 FORMAT('D')
 1006 FORMAT('R')
      END
```

OAK GROVE GRAVITY LINE 4-7-76 DATA BY T JONES AND Z MOORE
360 LINES TO BE PRINTED BY SUBROUTINE PLTR1

STATION NUMBER	ELEVATION FEET	ELEVATION METERS	LATTITUDE DEGREES	TERRAIN CORREC. MGALS	OBSERVED GRAVITY MGALS	THEORITICAL GRAVITY MGALS	BOUGUER CORREC. MGALS	FREE AIR CORREC. MGALS	FREE AIR ANOMALY MGALS	SIMPLE BOUGUER ANOMALY MGALS	COMPLETE BOUGUER ANOMALY MGALS
308	115.00	35.05	45.25731	.300	980611.640	980652.547	3.918	10.817	-30.090	-34.008	-33.708
307	107.00	32.61	45.26545	.300	980612.860	980653.282	3.645	10.064	-30.357	-34.003	-33.703
306	160.00	48.77	45.28243	.220	980614.100	980654.814	5.451	15.050	-25.665	-31.116	-30.896
305	168.00	51.21	45.29002	.110	980614.730	980655.500	5.724	15.802	-24.967	-30.691	-30.581
304	147.00	44.81	45.30309	.040	980615.940	980656.679	5.008	13.827	-26.913	-31.921	-31.881
303	268.00	81.69	45.33207	.080	980619.900	980659.295	9.130	25.208	-14.187	-23.318	-23.238
302	413.00	125.88	45.35730	.110	980613.760	980661.580	14.070	38.847	-8.973	-23.044	-22.934
301	370.00	112.78	45.36638	.700	980622.820	980662.438	12.606	34.802	-4.816	-17.421	-16.721
258	167.00	50.90	45.35837	.400	980633.600	980661.670	5.690	15.708	-12.362	-18.051	-17.651
257	160.00	48.77	45.35913	.420	980635.070	980661.738	5.451	15.050	-11.619	-17.070	-16.650
256	170.00	51.82	45.36084	.440	980635.910	980661.893	5.792	15.990	-9.992	-15.784	-15.344
255	175.00	53.34	45.36100	.460	980634.800	980661.907	5.962	16.460	-10.646	-16.609	-16.149
254	127.00	38.71	45.36084	.490	980640.300	980661.893	4.327	11.946	-9.647	-13.974	-13.484
253	125.00	38.10	45.36100	.510	980639.670	980661.907	4.259	11.757	-10.479	-14.738	-14.228
252	196.00	59.74	45.36248	.540	980636.850	980662.041	6.678	18.436	-6.755	-13.432	-12.892
251	221.00	67.36	45.36342	.560	980636.550	980662.125	7.529	20.787	-4.788	-12.317	-11.757
250	224.00	68.28	45.36462	.590	980636.190	980662.234	7.631	21.069	-4.974	-12.606	-12.016
249	271.00	82.60	45.36561	.620	980632.570	980662.323	9.233	25.490	-4.263	-13.496	-12.876
248	310.00	94.49	45.36638	.650	980629.790	980662.393	10.561	29.159	-3.444	-14.005	-13.355
247	352.00	107.29	45.36891	.670	980627.650	980662.621	11.992	33.109	-1.862	-13.854	-13.184
246	406.00	123.75	45.37000	.700	980624.270	980662.719	13.832	38.188	-.261	-14.093	-13.393
245	432.00	131.67	45.37044	.720	980623.290	980662.759	14.718	40.634	1.165	-13.553	-12.833
244	413.00	125.88	45.37171	.720	980624.850	980662.874	14.070	38.847	.823	-13.247	-12.527
243	440.00	134.11	45.37209	.710	980623.550	980662.906	14.990	41.386	2.028	-12.962	-12.252
242	474.00	144.48	45.37280	.700	980621.650	980662.972	16.149	44.584	3.242	-12.906	-12.206
241	505.00	153.92	45.37182	.690	980619.740	980662.884	17.205	47.500	4.357	-12.848	-12.158
240	558.00	170.08	45.37352	.680	980616.470	980663.037	19.011	52.485	5.918	-13.092	-12.412
239	562.00	171.30	45.37407	.670	980616.140	980663.087	19.147	52.862	5.915	-13.232	-12.562
238	600.00	182.88	45.37462	.660	980615.760	980663.136	20.441	56.436	9.060	-11.382	-10.722
237	628.00	191.41	45.37549	.650	980612.450	980663.215	21.395	59.070	8.305	-13.091	-12.441
236	662.00	201.78	45.37648	.640	980609.900	980663.304	22.554	62.268	8.863	-13.690	-13.050
235	706.00	215.19	45.38015	.710	980607.150	980663.636	24.053	66.406	9.951	-14.102	-13.392
234	694.00	211.53	45.38103	.780	980608.060	980663.715	23.644	65.278	9.623	-14.021	-13.241
233	692.00	210.92	45.38224	.850	980608.220	980663.824	23.576	65.090	9.485	-14.091	-13.241
232	671.00	204.52	45.38246	.930	980609.790	980663.844	22.860	63.114	9.060	-13.800	-12.870
231	682.00	207.87	45.38388	1.000	980608.760	980663.972	23.235	64.149	8.937	-14.299	-13.299
230	673.50	205.28	45.38553	1.070	980608.990	980664.121	22.945	63.349	8.218	-14.727	-13.657
229	659.00	200.86	45.38584	1.140	980609.730	980664.240	22.451	61.986	7.476	-14.975	-13.835
228	640.00	195.07	45.38755	1.210	980610.690	980664.304	21.804	60.198	6.585	-15.219	-14.009
227	622.00	189.59	45.38755	1.170	980611.840	980664.304	21.191	58.505	6.042	-15.149	-13.979
226	590.00	179.83	45.38761	1.120	980613.820	980664.309	20.101	55.495	5.006	-15.094	-13.974
225	540.00	164.59	45.38997	1.060	980617.160	980664.522	18.397	50.792	3.430	-14.967	-13.907
224	492.00	149.96	45.39062	1.030	980619.940	980664.581	16.762	46.278	1.637	-15.125	-14.095
223	442.00	134.72	45.39041	.990	980623.210	980664.562	15.058	41.575	.223	-14.836	-13.846
222	378.00	115.21	45.38969	.940	980626.550	980664.497	12.878	35.555	-2.392	-15.270	-14.330
221	340.00	103.63	45.39024	.900	980628.810	980664.546	11.583	31.980	-3.756	-15.340	-14.440
220	309.50	94.34	45.39051	.860	980630.860	980664.571	10.544	29.112	-4.599	-15.144	-14.284
219	263.00	80.16	45.39079	.820	980633.840	980664.596	8.960	24.738	-6.018	-14.978	-14.158
218	217.00	66.14	45.39106	.770	980636.930	980664.621	7.393	20.411	-7.280	-14.673	-13.903
217	200.00	60.96	45.39139	.730	980637.990	980664.650	6.814	18.812	-7.848	-14.662	-13.932
216	176.30	53.74	45.39189	.680	980639.750	980664.695	6.006	16.583	-8.363	-14.369	-13.689
215	178.00	54.25	45.39073	.640	980639.750	980664.591	6.064	16.743	-8.098	-14.162	-13.522
214	150.00	45.72	45.39106	.630	980641.590	980664.620	5.110	14.109	-8.922	-14.032	-13.402
213	134.00	40.84	45.39128	.610	980642.730	980664.640	4.565	12.604	-9.306	-13.872	-13.262
212	125.90	38.37	45.39194	.590	980643.360	980664.700	4.289	11.842	-9.498	-13.787	-13.197
211	120.00	36.58	45.39232	.570	[illegible]	980664.734	4.088	11.287	-9.767	-13.855	[illegible]

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210	116.00	35.36	45.39205	.560	980643.900	980664.710	3.952	10.911	-9.899	-13.851	-13.291
209	111.00	33.83	45.39172	.550	980644.130	980664.680	3.782	10.441	-10.109	-13.891	-13.341
208	88.00	26.82	45.39106	.530	980645.720	980664.620	2.998	8.277	-10.623	-13.621	-13.091
207	121.00	36.88	45.39084	.510	980643.390	980664.601	4.122	11.381	-9.829	-13.952	-13.442
206	124.00	37.80	45.39030	.500	980642.970	980664.552	4.225	11.665	-9.918	-14.143	-13.643
205	113.50	34.59	45.39331	.490	980644.010	980664.624	3.867	10.676	-10.138	-14.005	-13.515
204	74.80	22.80	45.39406	.480	980644.710	980664.893	2.548	7.036	-13.147	-15.696	-15.216
203	67.10	20.45	45.39457	.460	980647.540	980664.937	2.286	6.311	-11.086	-13.372	-12.912
202	38.50	11.73	45.39397	.450	980648.980	980664.883	1.312	3.621	-12.282	-13.593	-13.143
201	9.00	2.74	45.39380	.430	980650.960	980664.868	.307	.847	-13.041	-13.348	-12.918
69	8.15	2.48	45.39717	.430	980651.420	980665.172	.278	.767	-12.985	-13.263	-12.833
68	40.85	12.45	45.39811	.420	980649.350	980665.257	1.392	3.842	-12.055	-13.446	-13.026
67	57.05	17.39	45.39865	.400	980646.440	980665.306	1.944	5.366	-11.500	-13.443	-13.043
66	55.17	16.82	45.39898	.370	980648.570	980665.335	1.880	5.189	-11.576	-13.456	-13.086
65	77.02	23.48	45.39958	.340	980647.320	980665.390	2.624	7.245	-10.825	-13.449	-13.109
62	94.41	28.78	45.39794	.310	980646.030	980665.242	3.216	8.880	-10.331	-13.548	-13.238
61	78.27	23.86	45.39860	.270	980647.440	980665.301	2.667	7.362	-10.499	-13.166	-12.896
60	62.81	19.14	45.39887	.240	980648.620	980665.325	2.140	5.908	-10.798	-12.937	-12.697
59	67.53	20.58	45.39936	.200	980648.450	980665.370	2.301	6.352	-10.568	-12.869	-12.669
58	66.79	20.36	45.39980	.200	980648.090	980665.409	2.275	6.282	-11.037	-13.313	-13.113
57	70.79	21.58	45.40030	.210	980647.620	980665.455	2.412	6.659	-11.176	-13.588	-13.378
56	80.14	24.43	45.40112	.220	980647.120	980665.529	2.730	7.538	-10.871	-13.601	-13.381
55	98.65	30.07	45.40123	.230	980645.900	980665.539	3.361	9.279	-10.360	-13.720	-13.490
54	112.50	34.29	45.40166	.240	980645.100	980665.577	3.833	10.582	-9.896	-13.728	-13.488
53	121.05	36.90	45.40227	.250	980644.760	980665.632	4.124	11.386	-9.486	-13.611	-13.361
52	129.77	39.55	45.40287	.260	980644.420	980665.687	4.421	12.206	-9.060	-13.482	-13.222
51	149.95	45.70	45.40364	.270	980643.040	980665.756	5.109	14.104	-8.612	-13.720	-13.450
50	181.29	55.26	45.40396	.280	980641.410	980665.785	6.176	17.052	-7.323	-13.499	-13.219
49	196.81	59.99	45.40429	.260	980640.320	980665.815	6.705	18.512	-6.983	-13.688	-13.408
48	213.07	64.94	45.40473	.280	980639.270	980665.854	7.259	20.041	-6.543	-13.802	-13.522
47	233.78	71.26	45.40517	.270	980637.790	980665.894	7.965	21.989	-6.115	-14.080	-13.810
46	261.23	79.62	45.40566	.260	980635.930	980665.938	8.900	24.571	-5.437	-14.337	-14.077
44	287.67	87.68	45.40654	.250	980634.130	950666.016	9.801	27.056	-4.830	-14.630	-14.380
43	320.12	97.57	45.40708	.260	980631.940	980666.067	10.906	30.110	-4.016	-14.922	-14.662
42	329.38	100.40	45.40774	.270	980631.540	980666.126	11.222	30.981	-3.605	-14.826	-14.556
41	339.49	103.48	45.40845	.270	980630.890	980666.190	11.566	31.932	-3.368	-14.934	-14.664
40	349.52	106.53	45.40800	.280	980630.410	980666.150	11.908	32.876	-2.864	-14.772	-14.492
39	353.90	107.87	45.40966	.280	980630.200	980666.300	12.057	33.288	-2.812	-14.869	-14.589
38	348.87	106.34	45.40917	.280	980630.680	980666.255	11.886	32.815	-2.761	-14.646	-14.366
37	343.32	104.64	45.40993	.290	980630.500	980666.324	11.697	32.293	-3.231	-14.928	-14.638
36	325.29	99.15	45.41059	.300	980631.550	980666.383	11.082	30.597	-4.237	-15.319	-15.019
35	313.75	95.63	45.41114	.310	980632.420	980666.433	10.689	29.511	-4.502	-15.191	-14.881
34	297.63	90.72	45.41157	.320	980633.360	980666.472	10.140	27.995	-5.117	-15.257	-14.937
33	283.64	86.45	45.41212	.330	980634.230	980666.522	9.663	26.679	-5.612	-15.276	-14.946
32	267.94	81.67	45.41261	.340	980634.670	980666.566	9.128	25.202	-6.693	-15.822	-15.482
31	259.32	79.04	45.41294	.350	980634.950	980666.596	8.835	24.392	-7.254	-16.089	-15.739
30	225.18	68.63	45.41349	.350	980637.110	980666.645	7.672	21.180	-8.355	-16.026	-15.676
29	188.77	57.54	45.41398	.350	980638.910	980666.689	6.431	17.756	-10.024	-16.455	-16.105
28	158.79	48.40	45.41453	.320	980640.340	980666.739	5.410	14.936	-11.463	-16.873	-16.553
27	141.66	43.18	45.41508	.290	980640.890	980666.789	4.826	13.325	-12.574	-17.400	-17.110
26	105.31	32.10	45.41623	.270	980642.880	980666.893	3.588	9.905	-14.107	-17.695	-17.425
25	87.11	26.55	45.41623	.250	980642.390	980666.893	2.968	8.194	-16.309	-19.277	-19.027
24	85.94	26.19	45.41617	.230	980641.660	980666.887	2.928	8.084	-17.124	-20.052	-19.822
23	96.42	29.39	45.41617	.200	980640.590	980666.887	3.285	9.069	-17.228	-20.513	-20.313
22	99.06	30.20	45.41612	.180	980640.460	980666.883	3.376	9.319	-17.103	-20.479	-20.299
21	111.37	33.95	45.41612	.150	980639.270	980666.883	3.794	10.475	-17.137	-20.931	-20.781
20	132.74	40.46	45.41612	.130	980637.410	980666.883	4.522	12.486	-16.987	-21.509	-21.379
19	154.20	47.00	45.41606	.110	980635.760	980666.877	5.253	14.504	-16.613	-21.867	-21.757
18	154.05	46.95	45.41743	.110	980635.580	980667.001	5.248	14.490	-16.931	-22.179	-22.069
16	145.81	44.44	45.41746	.110	980635.840	980667.134	4.968	13.715	-17.629	-22.597	-22.487
14	115.99	35.35	45.42182	.100	980637.790	980667.397	3.952	10.910	-18.697	-22.649	-22.549
12	105.09	32.03	45.42376	.100	980638.370	980667.572	3.580	9.885	-19.318	-22.898	-22.798
10	112.93	34.42	45.42325	.100	980637.810	980667.526	3.847	10.622	-19.094	-22.941	-22.841
6	110.36	33.64	45.42314	.100	980637.930	980667.516	3.760	10.380	-19.206	-22.966	-22.866
6	123.49	37.64	45.42297	.110	980637.030	980667.501	4.207	11.615	-18.856	-23.063	-22.953
4	13?.10	[illegible]	45.42155	.120	980637.160	980667.373	4.?42	12.237	-17.676	-22.408	[illegible]

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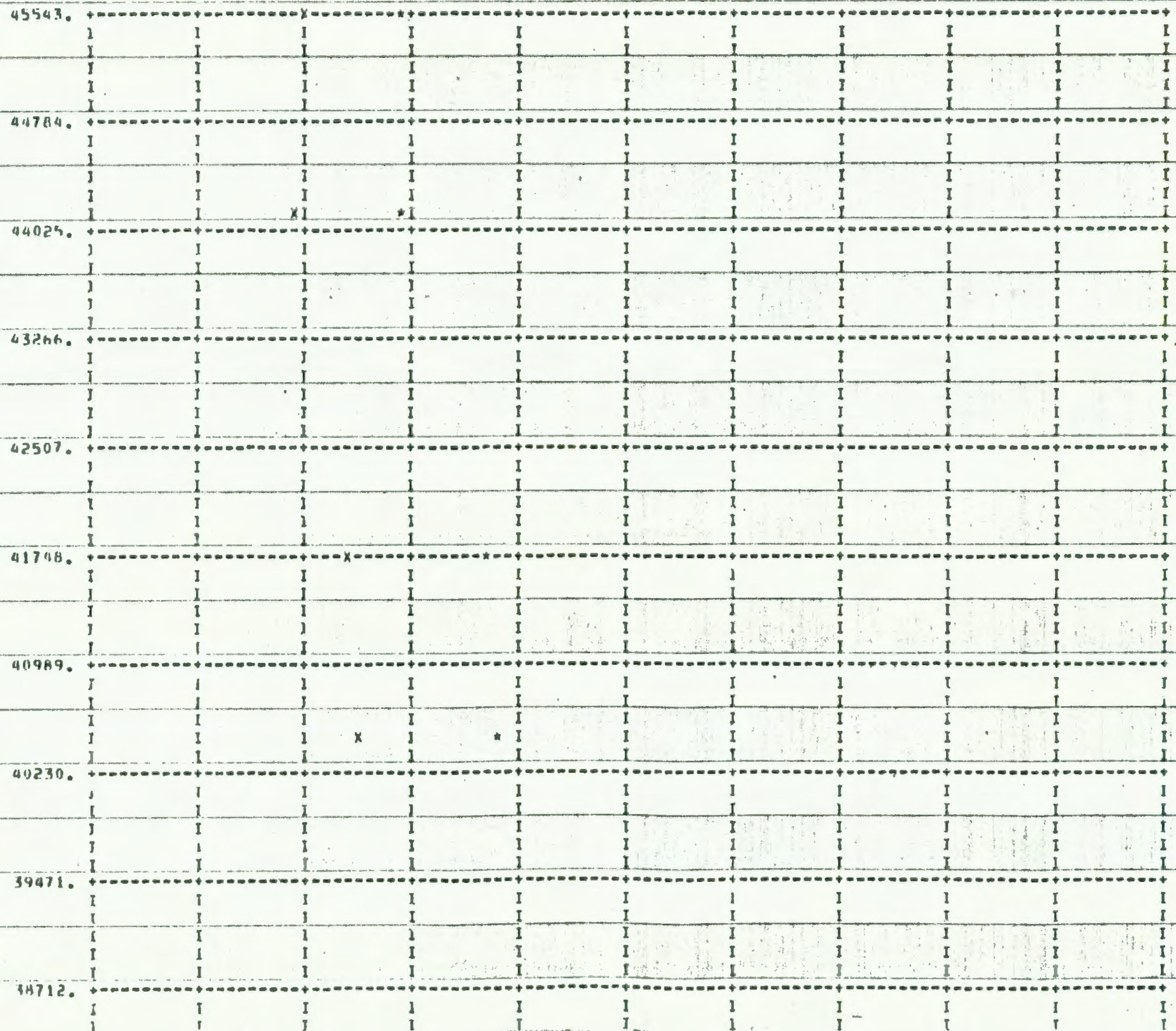
2	125.26	38.18	45.42204	.130	980638.040	980667.417	4.267	11.762	-17.595	-21.863	-21.733
1	139.07	42.39	45.42376	.130	980637.240	980667.572	4.738	13.081	-17.251	-21.989	-21.859
101	123.96	37.78	45.42675	.260	980637.940	980667.842	4.223	11.660	-18.243	-22.466	-22.206
102	289.26	88.17	45.43690	.340	980627.690	980668.758	9.855	27.208	-13.661	-23.515	-23.175
103	557.54	169.94	45.44576	1.020	980609.840	980669.560	18.995	52.442	-7.278	-26.273	-25.253
104	667.05	203.32	45.46129	.650	980602.700	980670.960	22.726	62.743	-5.517	-28.243	-27.593
105	430.51	131.22	45.46946	.540	980613.990	980671.698	14.667	40.494	-17.214	-31.881	-31.341
106	273.70	83.42	45.47686	.350	980620.760	980672.366	9.325	25.744	-25.861	-35.186	-34.836
108	244.34	74.47	45.49243	.650	980620.030	980673.771	8.324	22.983	-30.758	-39.083	-38.433
107	245.97	74.97	45.50461	.060	980620.190	980674.870	8.380	23.136	-31.544	-39.924	-39.864
109	250.06	76.22	45.52261	.050	980618.330	980676.495	8.519	23.521	-34.645	-43.164	-43.114
110	205.34	62.59	45.53406	.080	980621.960	980677.529	6.996	19.314	-36.254	-43.250	-43.170
111	82.77	25.23	45.54528	.130	980631.790	980678.541	2.820	7.785	-38.966	-41.786	-41.656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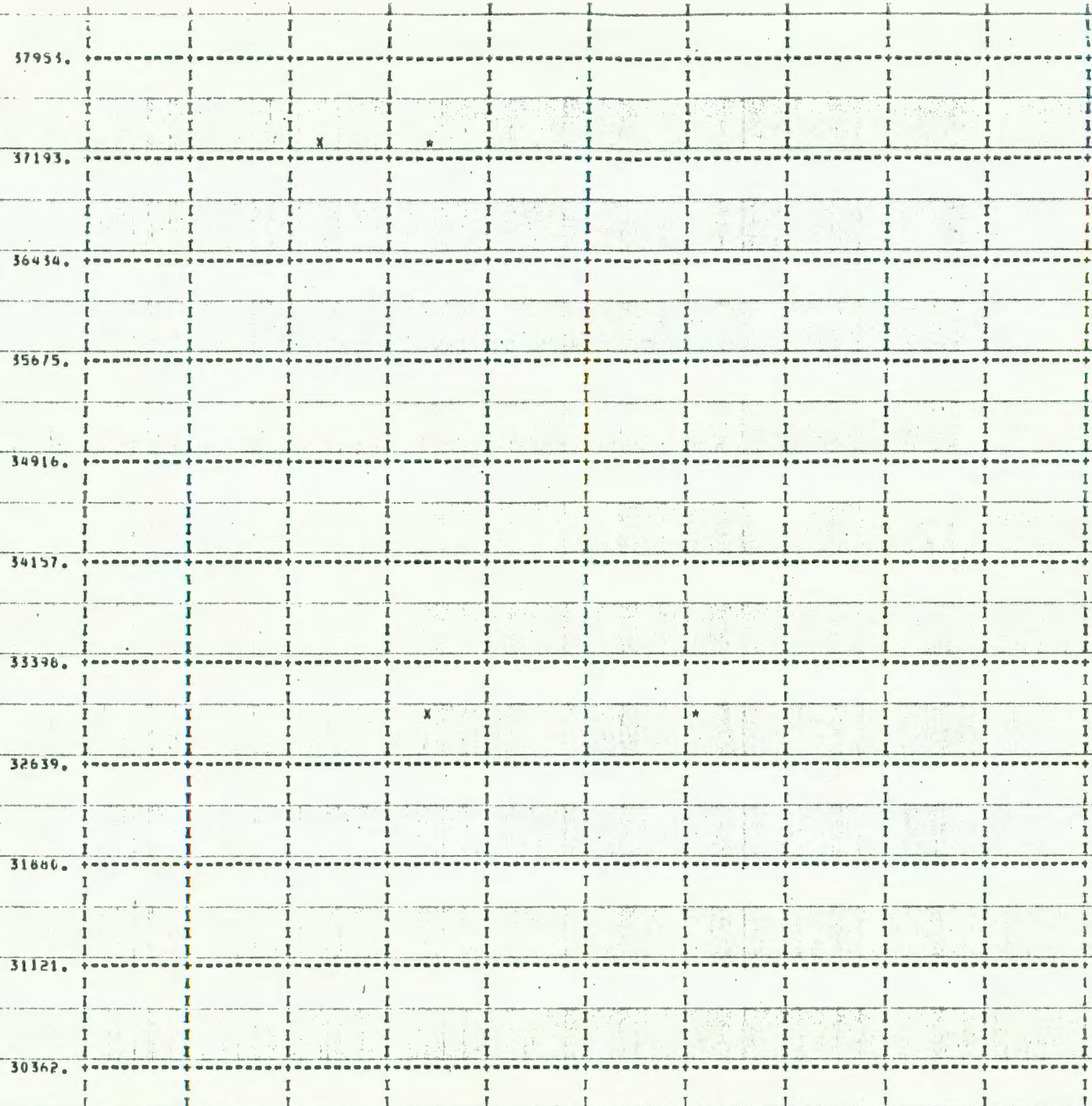
pt.2/12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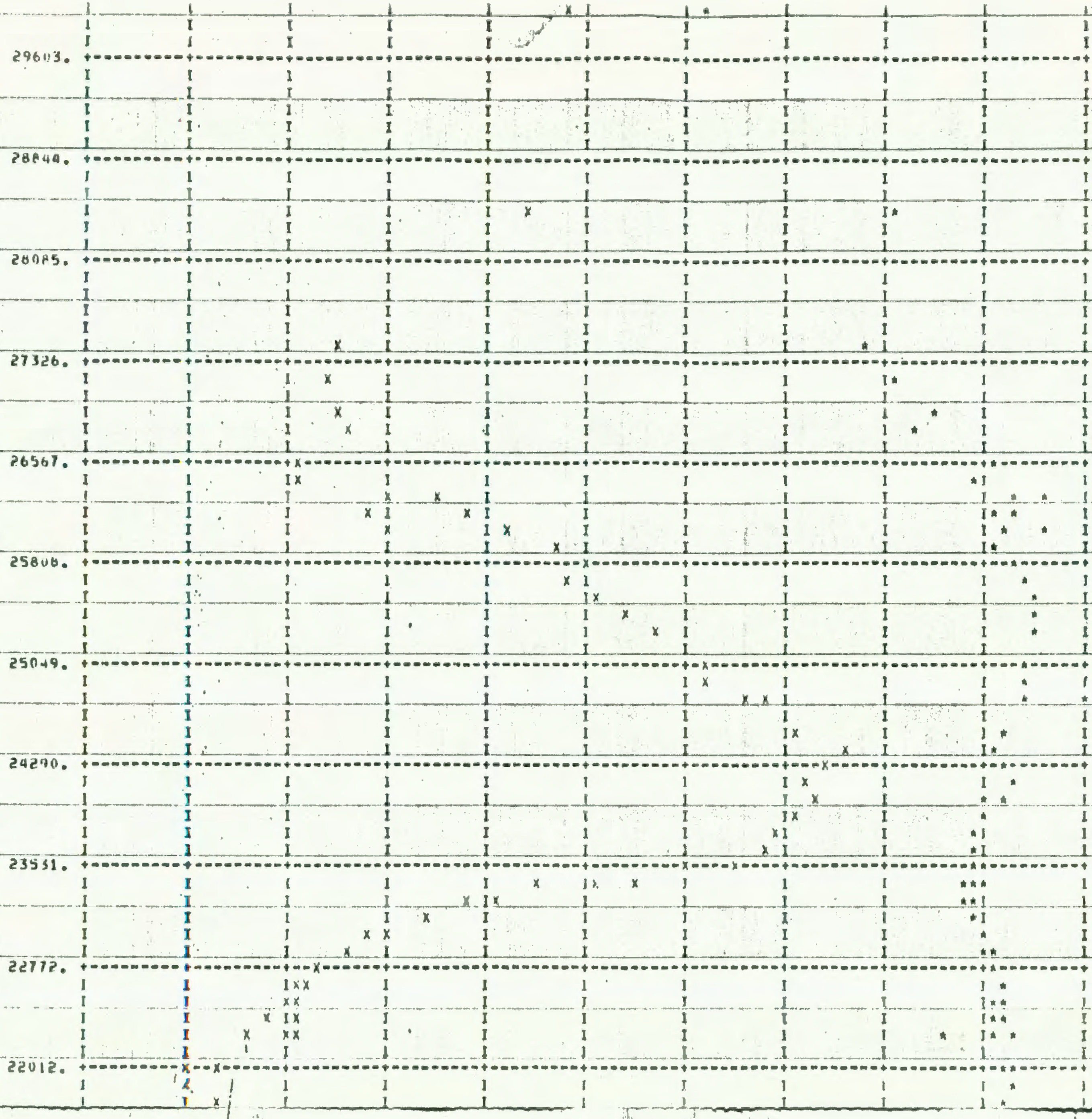
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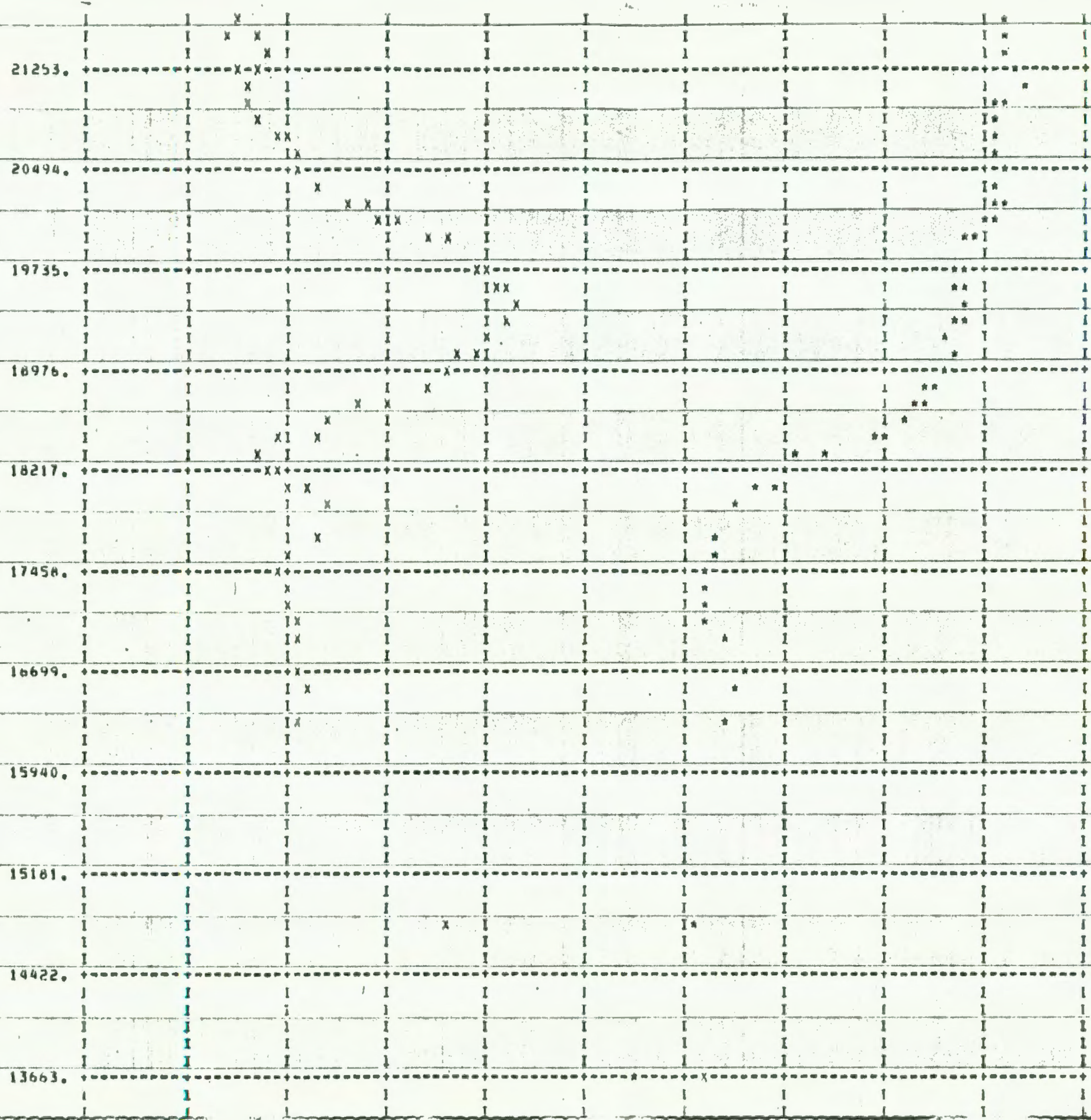
pr. 2/14



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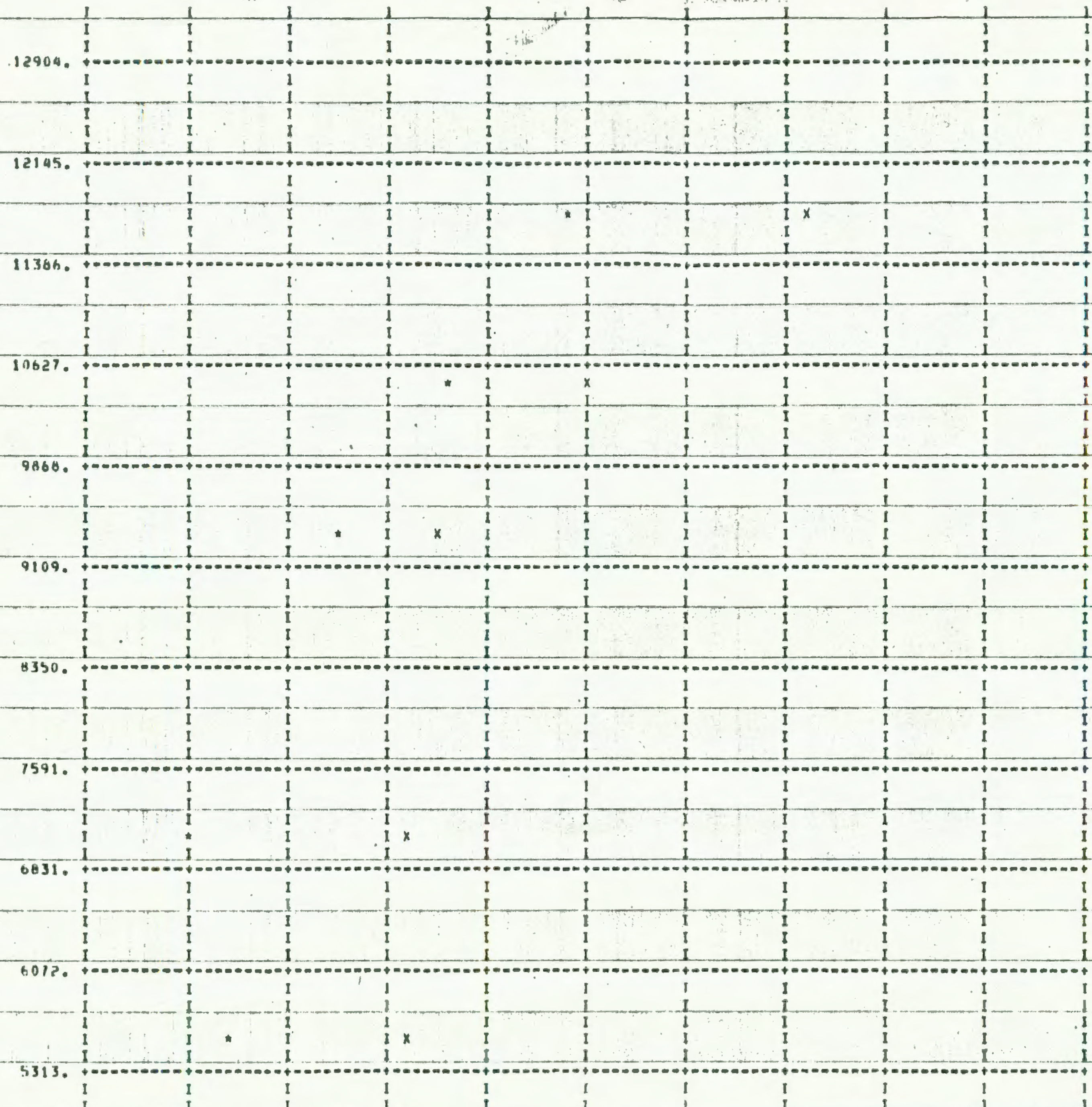
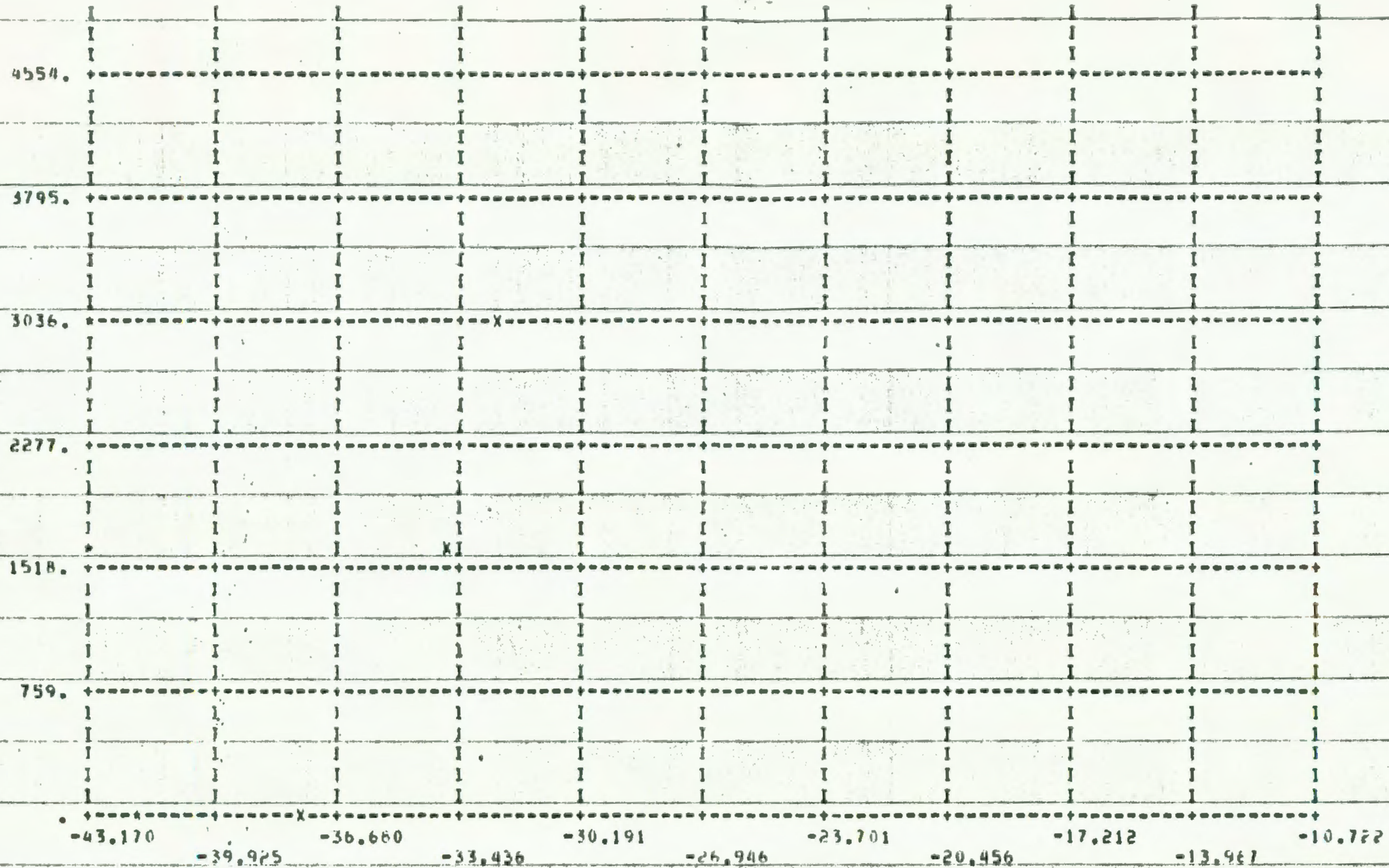


pr. 2/16



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-10.722

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************************    PORTLAND STATE UNIVERSITY - COMPUTING SERVICES CENTER  HARRIS / 220    ********************   382
**                                                                                                                   **   382
**                                                                                                                   **   382
**              JD.JONES                     27 MAY 77 18:14:07                                                      **   382
**                                                                                                                   **   382
**                                                                                                                   **   382
**                                                                                                                   **   382
**                JOB: 007744                                                                                        **   382
**                                                                                                                   **   382
**                                                                                                                   **   382
**                                                                                                                   **   382
**          JJJJJJ   DDDDD           JJJJJJ    OOOO    N    N   EEEEEE   SSSS                                        **   382
**              J    D    D              J    O    O   NN   N   E       S                                            **   382
**              J    D    D              J    O    O   N N  N   E        SSSS                                        **   382
**          J   J    D    D    ..    J   J    O    O   N  N N   EEEE         S                                       **   382
**          J   J    D    D    ..    J   J    O    O   N   NN   E       S    S                                       **   382
**           JJJ     DDDDD            JJJ      OOOO    N    N   EEEEEE   SSSS                                        **   382
**                                                                                                                   **   382
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**                                                                                                                   **   382
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JOB,BOUGUERFIT,5013A001;JD.JONESL#5000,T#100                                  27 MAY 77 18:10:45
===> $$*FORTRAN
```

```
C     BOUGUER GRAVITY FIT PROGRAM
C     THIS PROGRAM COMPUTES THE GRAVITATION ATTRACTION ACROSS THE SURFACE
C     OF A RECTANGLE COMPOSED OF A NUMBER OF ARTITRARLY SHAPED BLOCKS.
C     THE ORIGIN OF THE COORDINATE SYSTEM IS IN THE UPPER LEFT HAND
C     CORNER OF THE RECTANGLE.  Z IS POSITIVE DOWNWARDS
C     ALL DISTANCES ARE IN KILOMETERS.
C     IN ORDER TO ELEMINATE EDGE EFFECTS THE MODEL IS ORDINARLY EXTENDED
C     FOR 100 KM ON EITHER SIDE OF THE AREA OF INTEREST.
C     THIS PROGRAM IS EQUIPED TO SUBTRACT OUT TWO DIFFERENT REGIONAL
C     GRADIENTS FROM THE CALCULATED GRAVITY ANOMALY.  IF NO REGIONAL
C     GRADIENT CORRECTION IS DESIRED, ASSIGN GRAD1 AND GRAD2 TO 0
C
C
C                          EXPLANATION
C
C
C     DATA CARD SYMBOLS                                              FORMAT
C     SAM1,SAM2        CROSS SECTION NUMBER                          2A4
C     PX(1)            FIRST LOCATION WHERE GRAVITY IS TO BE COMPUTED    F6.0
C     STEP             DISTANCE BETWEEN POINT WHERE GRAVITY IS COMPUTED  F4.0
C     M                TOTAL NUMBER OF COMPUTED POINTS               I5
C     N                NUMBER OF BLOCKS IN MODEL                     I5
C     GRAD1            FIRST REGIONAL GRADIENT                       F10.0
C     GRAD2            SECOND REGIONAL GRADIENT                      F10.0
C     GRADS            LOCATION OF CHANGE IN REGIONAL GRADIENT       F10.0
C     RHO              BLOCK DENSITY                                 F5.0
C     J                NUMBER OF CORNERS IN BLOCK                    I3
C     ISALT            BLOCK NUMBER                                  I2
C     X(I)             X COORDINATE OF BLOCK CORNER                  10F8.0
C     Z(I)             Z COORDINATE OF BLOCK CORNER                  10F8.0
C
C
C
C          THE LAST INPUT CARD GIVERS THE FOUR COORDINATES OF THE TOTAL
C          RECTANGLE          FORMAT 4F8.0
C
C
C
C      THE MODEL CHECK SHOULD BE SYMMETRICAL AROUND THE CENTER OF THE
C     RECTANGLE WITH NO LARGE DISCONTINUITIES.
C
C
C
      DIMENSION PX(900),X(900),Z(900),TOT(900),CHK1(900),CHK2(900),
     1CHK3(900),TIT(900)
    1 FORMAT(2A4,F6.0,F4.0,2I5)
  201 FORMAT(1H1,3X,2A4,F9.2,2X,F9.2,2X,I4,2X,I4)
    2 FORMAT (F5.0,I3,6X,I2)
  900 FORMAT (1H ,I3,F8.3)
  301 FORMAT (10F8.0)
  205 FORMAT (1H0,'MODEL CHECK',/' STATION 1 ',F12.6,/' STATION 2 ',
     1F12.6,' STATION 3 ',F12.6)
202   FORMAT (1H0,6F12.3)
200   FORMAT (1H ,3F12.4)
      INN=3
      INN=6
      INN=4
```

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```
      INN=2
      IAN=5
      INN=1
      IO=6
      PI = 3.1415927
  400 CONTINUE
      READ (7,1) SAM1,SAM2,PX(1),STEP,M,N
      WRITE (6,201) SAM1,SAM2,PX(1),STEP,M,N
      READ (7,801) GRAD1, GRAD2, GRADS
801   FORMAT (3F10.0)
      WRITE (6,802) GRAD1,GRAD2,GRADS
802   FORMAT (' ', 'GRAD1= ', F10.3,'   GRAD2= ',F10.3,'   GFADS= ',F10.
     13)
      TIT(1)=0.
      TOT(1)=0.
      DO 90 I=2,M
      PX(I)=PX(I-1)+STEP
      TIT(I)=0.
   90 TOT(I)=0.
      JJJ=0
   52 DO 106 IN=1,N
      IF (JJJ-1) 71,50,71
   71 READ (7,2) RHO,J,ISALT
      WRITE (6,900) ISALT,RHO
      READ (7,301) (X(I),Z(I),I=1,J)
      WRITE (6,202) (X(I),Z(I),I=1,J)
   50 K=J+1
      X(K)=X(1)
      Z(K)=Z(1)
      SUM=0.
      DO 101 I=1,M
      DO 5 JK=1,K
    5 X(JK)=X(JK)-PX(I)
      DO 122 JK=1,K
      J=JK
      IF (X(JK)) 6,7,8
    6 TH = ATAN(Z(JK)/X(JK))+PI
      IF (PI-TH) 72,72,9
   72 TH=PI
      GO TO 9
    7 TH = .5*PI

      GO TO 9
    8 TH = ATAN(Z(JK)/X(JK))
    9 IF (JK-1) 10,73,10
   73 TH1=TH
      GO TO 122
   10 TH2=TH
      L=JK-1
      A=Z(JK)-Z(L)
      B=X(JK)-X(L)
      JJ=5
      IF (X(L)) 74,75,74
   75 JJ=1
   74 IF (X(JK)) 76,77,76
   77 JJ=2
   76 IF (A) 78,79,78
```

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```
   79 JJ=3
   78 IF (B) 80,81,80
   81 JJ=4
   80 IF (TH1-TH2) 19,62,19
   82 S=0.
      GO TO 102
   19 IF (X(L)) 22,83,22
   83 IF (Z(L)) 22,84,22
   84 S=0.
      GO TO 102
   22 IF (X(J)) 25,85,25
   85 IF (Z(J)) 25,86,25
   86 S=0.
      GO TO 102
   25 GO TO (26,27,28,29,30),JJ
   26 S=(X(J)*X(J)*Z(L)/(A*A+X(J)*X(J)))*(TH2-.5*PI+(A/X(J))*(ALOG(Z(L))
     1-.5*ALOG(X(J)*X(J)+Z(J)*Z(J))))
      GO TO 102
   27 S=(X(L)*X(L)*Z(J)/(A*A+X(L)*X(L)))*(TH1-.5*PI-(A/X(L))*(ALOG(Z(J))
     1-.5*ALOG(X(L)*X(L)+Z(L)*Z(L))))
      S=-S
      GO TO 102
   28 S=Z(L)*(TH2-TH1)
      GO TO 102
   29 V=      ((Z(J)*Z(J)+X(J)*X(J))/(Z(L)*Z(L)+X(L)*X(L)))**.5
      S=X(L)*ALOG((X(L)/X(J))*V)
      GO TO 102
   30 T=X(J)-(Z(J)*B/A)
      U=B*A/(B*B+A*A)
      V=TH1-TH2
      W=(A/B)*.5*ALOG((Z(J)*Z(J)+X(J)*X(J))/(Z(L)*Z(L)+X(L)*X(L)))
      S=T*U*(V+W)
  102 SUM=SUM+S
      TH1=TH2
  122 CONTINUE
      DO 103 J=1,K
  103 X(J)=X(J)+PX(I)
      IF (I-1) 60,87,60
   87 CHK1(IN)=SUM
      IF (JJJ-1) 60,101,60
   60 IF(I-M/2) 61,88,61
   88 CHK2(IN)=SUM
   61 IF (I-M) 62,89,62
   89 CHK3(IN)=SUM
 62   DUM=SUM*13.346
      TIT(I)=TIT(I)+DUM
      SUM=SUM*RHO*13.346
      TOT(I)=TOT(I)+SUM
  101 SUM=0.
  106 CONTINUE
      IF (JJJ) 53,91,53
 91   CONTINUE
      TOT(1)=TOT(1)-GRAD1
      CON=GRADS*GRAD1
      DO 1000 KT=2,M
      IF (KT*STEP-GRADS)809,809,808
 809  TOT(KT)=TOT(KT)-GRAD1*KT*STEP
```

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```
      KXT=KT
      GO TO 1000
  808 KKT=KT-KXT
      TOT(KT)=TOT(KT)-GRAD2*KKT*STEP-CON
 1000 TIT(KT)=TIT(KT)-TIT(1)
      TOT(KT)=TOT(KT)-PX(KT)
      TIT(1)=0.
      WRITE (6,200) (PX(I),TOT(I),TIT(I),I=1,M)
      JJJ=1
      TCHK1=0.
      TCHK2=0.
      TCHK3=0.
      DO 51 I=1,N
      TCHK1=TCHK1+CHK1(I)
      TCHK2=TCHK2+CHK2(I)
   51 TCHK3=TCHK3+CHK3(I)
      READ(7,301)(X(I),Z(I),I=1,4)
      M=1
      J=4
      GO TO 52
   53 R1=TCHK1-CHK1(1)
      R2=TCHK2-CHK2(1)
      R3=TCHK3-CHK3(1)
      WRITE (6,205) R1,R2,R3
      IQ=IQ+1
      IF (IQ-INN) 400,401,401
  401 CONTINUE
      CALL EXIT
      END
```

```
   OG M44      100.00          .10    461     12
 GRAD1=          .853   GRAD2=         .638   GRADS=        29.000
   1  2.300
       0.000       0.000     109.800         0.000     100.000        .170
       0.000        .170
   2  2.800
       0.000        .170     100.000          .170     109.800       0.000
     127.200       0.000     127.200          .040     121.000        .040
     118.500        .080     109.800          .230     100.000        .400
       0.000        .400
   3  2.400
       0.000        .400     100.000          .400     109.000        .230
     118.500        .040     109.300         1.100     100.000       1.060
       0.000       1.060
   4  2.500
       0.000       1.060     100.000         1.060     109.300       1.100
      99.400       1.650       0.000         1.650
   5  2.780
      99.400       1.650     109.300         1.100     118.500        .080
     118.500       1.000     127.200         1.485     127.200       1.400
     130.000       1.400     134.000         1.550     137.000        .380
     139.000        .350     144.000          .315     146.000        .200
     150.000       0.000     246.000         0.000     246.000       3.130
     146.000       3.130     110.000         2.850
   6  2.500
       0.000       1.650      99.400         1.650     110.000       2.850
       0.000       2.850
   7  2.800
       0.000       2.850     110.000         2.850     146.000       3.130
     246.000       3.130     246.000         5.000       0.000       5.000
   9  2.300
     128.800       0.000     149.000         0.000     146.000        .150
     144.000        .240     139.000          .200     135.500        .200
     130.300        .100     128.800          .078
  10  2.800
     127.200        .160     128.800          .150     128.800        .078
     130.300        .100     135.500          .200     139.000        .200
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pT.3/7

	144.000	.240	146.000	.150	149.000	0.000
	150.000	0.000	146.000	.200	144.000	.315
	139.000	.350	137.000	.380	135.500	.400
	130.300	.330	128.800	.308	128.800	.380
	127.200	.390				
18	3.000					
	118.500	.080	121.000	.040	127.200	.040
	127.200	1.485	118.500	1.000		
24	3.000					
	127.200	.390	128.800	.380	128.800	.308
	130.300	.330	135.500	.400	137.000	.380
	134.000	1.550	130.000	1.400	127.200	1.400
25	2.200					
	127.200	0.000	128.800	0.000	128.800	.150
	127.200	.160				
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	100.1000	546.1776	.0009			
	100.2000	546.2216	.0018			
	100.3000	546.2695	.0026			
	100.4000	546.3204	.0035			
	100.5000	546.3737	.0043			
	100.6000	546.4291	.0052			
	100.7000	546.4866	.0061			
	100.8000	546.5458	.0069			
	100.9000	546.6065	.0077			
	101.0000	546.6696	.0086			
	101.1000	546.7338	.0094			
	101.2000	546.7994	.0102			
	101.3000	546.8663	.0111			
	101.4000	546.9346	.0119			
	101.5000	547.0040	.0127			
	101.6000	547.0746	.0135			
	101.7000	547.1461	.0143			
	101.8000	547.2185	.0151			
	101.9000	547.2919	.0159			
	102.0000	547.3661	.0167			
	102.1000	547.4410	.0175			
	102.2000	547.5166	.0183			
	102.3000	547.5929	.0191			
	102.4000	547.6698	.0199			
	102.5000	547.7473	.0206			
	102.6000	547.8252	.0214			
	102.7000	547.9037	.0222			
	102.8000	547.9825	.0229			
	102.9000	548.0619	.0237			
	103.0000	548.1416	.0245			
	103.1000	548.2216	.0252			
	103.2000	548.3019	.0259			
	103.3000	548.3826	.0267			

519419

pt.3/8

103.9000	548.8707	.0310
104.0000	548.9526	.0318
104.1000	549.0347	.0325
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104.3000	549.1990	.0339
104.4000	549.2811	.0346
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104.9000	549.6924	.0380
105.0000	549.7745	.0337
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105.2000	549.9387	.0400
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105.9000	550.5100	.0445
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106.2000	550.7527	.0464
106.3000	550.8333	.0470
106.4000	550.9136	.0476
106.5000	550.9936	.0482
106.6000	551.0739	.0488
106.7000	551.1537	.0494
106.8000	551.2333	.0500
106.9000	551.3127	.0506
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107.1000	551.4711	.0518
107.2000	551.5500	.0524
107.3000	551.6289	.0530
107.4000	551.7076	.0535
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107.7000	551.9434	.0552
107.8000	552.0219	.0558
107.9000	552.1005	.0564
108.0000	552.1793	.0569
108.1000	552.2584	.0575
108.2000	552.3378	.0580
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108.6000	552.6509	.0601
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108.8000	552.8279	.0612
108.9000	552.9133	.0617
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109.2000	553.1797	.0632
109.3000	553.2722	.0637
109.4000	553.3667	.0642
109.5000	553.4633	.0647
109.6000	553.5618	.0652
109.7000	553.6621	.0657
109.8000	553.7645	.0662
109.9000	553.8322	.0666

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110.5000	554.2583	.0694
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111.4000	554.9250	.0733
111.5000	554.9994	.0738
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111.7000	555.1478	.0746
111.8000	555.2219	.0750
111.9000	555.2959	.0754
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112.5000	555.7391	.0777
112.6000	555.8130	.0781
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112.8000	555.9606	.0788
112.9000	556.0344	.0792
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113.6000	556.5548	.0817
113.7000	556.6299	.0820
113:8000	556.7052	.0823
113.9000	556.7806	.0826
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114.3000	557.0867	.0839
114.4000	557.1642	.0842
114.5000	557.2422	.0845
114.6000	557.3207	.0848
114.7000	557.3998	.0851
114.8000	557.4795	.0854
114.9000	557.5599	.0857
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115.1000	557.7230	.0863
115.2000	557.8058	.0866
115.3000	557.8895	.0868
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115.5000	558.0602	.0874
115.6000	558.1473	.0877
115.7000	558.2357	.0879
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115.9000	558.4172	.0884
116.0000	558.5105	.0887
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116.3000	558.8031	.0894
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[illegible]	[illegible]	[illegible]

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117.7000	560.7693	.0924
117.8000	561.0028	.0926
117.9000	561.2651	.0927
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118.1000	561.9102	.0931
118.2000	562.3140	.0933
118.3000	562.8101	.0934
118.4000	563.4209	.0936
118.5000	564.1747	.0938
118.6000	564.8864	.0939
118.7000	565.4120	.0941
118.8000	565.8056	.0942
118.9000	566.1110	.0944
119.0000	566.3528	.0945
119.1000	566.5474	.0946
119.2000	566.7056	.0948
119.3000	566.8359	.0949
119.4000	566.9436	.0950
119.5000	567.0331	.0952
119.6000	567.1078	.0953
119.7000	567.1703	.0954
119.8000	567.2225	.0955
119.9000	567.2664	.0956
120.0000	567.3030	.0957
120.1000	567.3334	.0958
120.2000	567.3585	.0959
120.3000	567.3790	.0960
120.4000	567.3955	.0961
120.5000	567.4094	.0962
120.6000	567.4132	.0963
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120.8000	567.4293	.0964
120.9000	567.4309	.0965
121.0000	567.4233	.0966
121.1000	567.4171	.0967
121.2000	567.4021	.0967
121.3000	567.3850	.0968
121.4000	567.3663	.0968
121.5000	567.3462	.0969
121.6000	567.3247	.0969
121.7000	567.3020	.0970
121.8000	567.2783	.0970
121.9000	567.2534	.0971
122.0000	567.2277	.0971
122.1000	567.2009	.0971
122.2000	567.1733	.0972
122.3000	567.1449	.0972
122.4000	567.1156	.0972
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122.6000	567.0547	.0972
122.7000	567.0232	.0972
122.8000	566.9908	.0973
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123.6000	566.7074	.0972

PT.3/11

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124.2000	565.4645	.0970
124.3000	565.4213	.0969
124.4000	565.3771	.0969
124.5000	565.3319	.0968
124.6000	565.2858	.0968
124.7000	565.2395	.0967
124.8000	565.1933	.0966
124.9000	566.1409	.0966
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125.3000	565.9233	.0962
125.4000	565.8717	.0962
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125.6000	565.7510	.0960
125.7000	565.6869	.0959
125.8000	565.6209	.0958
125.9000	565.5497	.0957
126.0000	565.4755	.0955
126.1000	565.3946	.0954
126.2000	565.3121	.0953
126.3000	565.2206	.0952
126.4000	565.1292	.0951
126.5000	565.0082	.0949
126.6000	564.8793	.0948
126.7000	564.7274	.0947
126.8000	564.5391	.0945
126.9000	564.2876	.0944
127.0000	563.9156	.0943
127.1000	563.2595	.0941
127.2000	561.4839	.0940
127.3000	559.7108	.0938
127.4000	559.0614	.0937
127.5000	558.6980	.0935
127.6000	558.4562	.0933
127.7000	558.2775	.0932
127.8000	558.1361	.0930
127.9000	558.0193	.0928
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128.2000	557.7645	.0923
128.3000	557.7079	.0921
128.4000	557.6698	.0919
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128.6000	557.7018	.0915
128.7000	557.8633	.0913
128.8000	558.3658	.0911
128.9000	558.8550	.0908
129.0000	559.0090	.0906
129.1000	559.0385	.0904
129.2000	559.0151	.0902
129.3000	558.9646	.0900
129.4000	558.8990	.0897
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129.8000	558.5665	.0888
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130.1000	558.2871	.0880
130.2000	[illegible]	.0877

PT.3/12

130.3000	558.0922	.0875
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131.1000	557.2468	.0852
131.2000	557.1351	.0849
131.3000	557.0245	.0846
131.4000	556.9176	.0843
131.5000	556.8002	.0840
131.6000	556.6862	.0837
131.7000	556.5709	.0834
131.8000	556.4561	.0831
131.9000	556.3357	.0827
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132.3000	555.8429	.0814
132.4000	555.7134	.0811
132.5000	555.5823	.0807
132.6000	555.4476	.0804
132.7000	555.3096	.0800
132.8000	555.1683	.0797
132.9000	555.0232	.0793
133.0000	554.8739	.0789
133.1000	554.7260	.0786
133.2000	554.5614	.0782
133.3000	554.3975	.0778
133.4000	554.2260	.0774
133.5000	554.0525	.0771
133.6000	553.8707	.0767
133.7000	553.6823	.0763
133.8000	553.4867	.0759
133.9000	553.2836	.0755
134.0000	553.0735	.0751
134.1000	552.8553	.0747
134.2000	552.6294	.0743
134.3000	552.3956	.0739
134.4000	552.1539	.0734
134.5000	551.9045	.0730
134.6000	551.6475	.0726
134.7000	551.3832	.0722
134.8000	551.1116	.0717
134.9000	550.8337	.0713
135.0000	550.5496	.0709
135.1000	550.2599	.0704
135.2000	549.9656	.0700
135.3000	549.6677	.0695
135.4000	549.3684	.0691
135.5000	549.0697	.0686
135.6000	548.7732	.0681
135.7000	548.4778	.0677
135.8000	548.1819	.0672
135.9000	547.8842	.0667
136.0000	547.5840	.0662
136.1000	547.2813	.0658
136.2000	546.9762	.0653
136.3000	546.6693	.0648
136.4000	546.3611	.0643
136.5000	546.0529	.0638
136.6000	545.7463	.0633
136.7000	545.4442	.0628

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136.9000	544.8691	.0613
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137.1000	544.3665	.0607
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137.3000	543.9551	.0597
137.4000	543.7784	.0592
137.5000	543.6167	.0586
137.6000	543.4672	.0581
137.7000	543.3275	.0575
137.8000	543.1960	.0570
137.9000	543.0712	.0564
138.0000	542.9521	.0559
138.1000	542.8376	.0553
138.2000	542.7273	.0548
138.3000	542.6205	.0542
138.4000	542.5166	.0536
138.5000	542.4153	.0530
138.6000	542.3162	.0525
138.7000	542.2186	.0519
138.8000	542.1223	.0513
138.9000	542.0264	.0507
139.0000	541.9301	.0501
139.1000	541.8326	.0495
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139.3000	541.6364	.0483
139.4000	541.5386	.0477
139.5000	541.4412	.0471
139.6000	541.3445	.0463
139.7000	541.2465	.0458
139.8000	541.1526	.0452
139.9000	541.0580	.0446
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140.1000	540.8701	.0433
140.2000	540.7779	.0427
140.3000	540.6843	.0420
140.4000	540.5922	.0414
140.5000	540.5006	.0407
140.6000	540.4094	.0400
140.7000	540.3186	.0394
140.8000	540.2263	.0387
140.9000	540.1383	.0380
141.0000	540.0467	.0374
141.1000	539.9595	.0367
141.2000	539.8707	.0360
141.3000	539.7822	.0353
141.4000	539.6941	.0346
141.5000	539.6062	.0339
141.6000	539.5167	.0332
141.7000	539.4315	.0325
141.8000	539.3447	.0318
141.9000	539.2582	.0311
142.0000	539.1720	.0304
142.1000	539.0862	.0297
142.2000	539.0007	.0290
142.3000	538.9155	.0282
142.4000	538.8308	.0275
142.5000	538.7465	.0268
142.6000	538.6625	.0260
142.7000	538.5791	.0253
142.8000	538.4961	.0245
142.9000	538.4138	.0238
143.0000	538.3320	.0230
143.1000	538.2512	.0223
143.2000	538.1713	.0215
143.3000	538.0924	.0207

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[illegible]	537.[illegible]	.0192
143.6000	537.8667	.0184
143.7000	537.7975	.0175
143.8000	537.7336	.0163
143.9000	537.6783	.0160
144.0000	537.6310	.0152
144.1000	537.6055	.0144
144.2000	537.5865	.0136
144.3000	537.5800	.0126
144.4000	537.5775	.0120
144.5000	537.5792	.0112
144.6000	537.5839	.0103
144.7000	537.5908	.0095
144.8000	537.5994	.0087
144.9000	537.6095	.0078
145.0000	537.6207	.0070
145.1000	537.6323	.0061
145.2000	537.6460	.0053
145.3000	537.6598	.0044
145.4000	537.6745	.0036
145.5000	537.6896	.0027
145.6000	537.7054	.0018
145.7000	537.7219	.0010
145.8000	537.7394	.0001
145.9000	537.7579	-.0008
146.0000	537.7785	-.0017

MODEL CHECK
STATION 1 -.000063
STATION 2 -.000060 STATION 3 -.000115

pt4/1

```
***********************    PORTLAND STATE UNIVERSITY - COMPUTING SERVICES CENTER  HARRIS / 220    ********************      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                         JO.JONES                    27 MAY 77 18:15:04                                              **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                          JOB: 007743                                                                                **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                JJJJJJ   DDDDD          JJJJJJ   0000    N    N  EEEEEE   SSSS                                       **      383
**                    J    D    D             J   0    0   NN   N  E       S                                           **      383
**                    J    D    D             J   0    0   N N  N  E        SSSS                                       **      383
**                J   J    D    D   ..    J   J   0    0   N  N N  EEEE         S                                      **      383
**                J   J    D    D   ..    J   J   0    0   N   NN  E       S    S                                      **      383
**                 JJJ     DDDDD           JJJ     0000    N    N  EEEEEE   SSSS                                       **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
**                                                                                                                     **      383
*************************************************************************************************************************      383
JOB.FREEAIRFIT,5013A001,JO.JONESL#20000,T#200                                27 MAY 77 18:10:18
===> $3*FORTRAN
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pT.4/2


```
C        FREE AIR GRAVITY FIT PROGRAM
C   THIS PROGRAM COMPUTES THE GRAVITATIONAL ATTRACTION ACROSS THE SURFACE
C   OF A RECTANGLE COMPOSED OF A NUMBER OF ARBITRARLY SHAPED BLOCKS.
C   THE TERRAIN MAY BE ANCLUDED ALONG THE TOP OF THE RECTANGLE.
C   THE ORIGINE OF THE COORDINATE SYSTEM IS IN THE UPPER LEFT HAND
C   CORNER OF THE RECTANGLE.  Z IS POSITIVE DOWNWARDS.  ALL DISTANCES
C   ARE IN KM.  THE RECTANGLE IS ORDINARLY EXTENDED ABOUT 100 KM
C   ON EITHER SIDE OF THE AREA OF INTEREST IN ORDER TO ELEMINATE EDGE EFFECTS.
C   THE MODEL CHECK HAS NO SIGNIFICANCE WHEN THE TOPOGRAPHY IS INCLUDED.
C
C
C                         EXPLANATION
C
C
C        DATA CARD SYMBOL                                     FORMAT
C   DRCX       COMMENT CARD                                   20A4
C   GRAD1      FIRST REGIONAL GRADIENT                        F10.0
C   GRAD2      SECOND REGIONAL GRADIENT                       F10.0
C   GRADS      CHANGE IN REGIONAL GRADIENT                    F10.0
C   SAM        CROSS SECTION NUMBER                           F10.0
C   M          TOTAL NUMBER OF COMPUTED POINTS                I5
C   N          TOTAL NUMBER OF BLOCKS IN MODEL                I5
C   PX         X COORDINATE OF CALCULATED POINT               F10.0
C   PZ         Z COORDINATE OF CALCULATED POINT               F10.0
C   RHO        BLOCK DENSITY                                  F5.2
C   J          NUMBER OF CORNERS IN BLOCK                     I3
C   ISALT      BLOCK NUMBER                                   I5
C   X          X COORDINATE OF BLOCK CORNER                   F10.0
C   Z          Z COORDINATE OF BLOCK CORNER                   F10.0
C
C
C
      DIMENSION PX(200),PZ(200),X(400),Z(400),TOT(200),TIT(200),DRCX(20)
      READ(2,901)(DRCX(J),J=1,20)
901   FORMAT (20A4)
      WRITE(5,902)(DRCX(J),J=1,20)
902   FORMAT ('1',20A4////)
100   READ (2,469) GRAD1,GRAD2,GRADS
469   FORMAT (3F10.0)
      IF (GRAD1.EQ.0.)GO TO 9999
      WRITE (5,468) GRAD1,GRAD2,GRADS
468   FORMAT (' ',F10.3,' =GRAD1',F10.3,' =GRAD2',F10.3,' =GRADS')
      PI=3.1415927
      PI2=2.*PI
      READ (2,1) SAM,M,N
1     FORMAT (F10.0,2I5)
      DO 721 J=1,M
721   CONTINUE
903   WRITE (5,201) SAM,M,N
201   FORMAT (' ',F10.2,' CROSS SECTION ID NUMBER'/,I9,'   POINTS AT WHI
     1CH GRAVITY IS TO BE COMPUTED'/,I9,2X,' BLOCKS IN MODEL'//////)
      DO 52 I=1,M
      READ (2,301) PX(I) ,PZ(I)
301   FORMAT (2F10.0)
      WRITE (5,303) PX(I),PZ(I)
303   FORMAT (' ',2F10.4)
      TIT(I)=0.
```

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```
      TOT(I)=0.
52    CONTINUE
      DO 106 IN=1,N
      READ (2,2) RHO,J,ISALT
2     FORMAT (F5.2,I3,I5)
      WRITE (5,304)RHO,J,ISALT
304   FORMAT ('0'F6.2,' DENSITY'/ I7,' CORNERS IN BLOCK'/I7,' BLOCK NUMB
     1ER'///)
      WRITE (5,305)
305   FORMAT (' ',7X,'X',9X,'Z',6X,' COORDINATES OF BLOCK CORNERS')
      DO 300 I=1,J
      READ (2,301) X(I),Z(I)
      WRITE (5,306) X(I),Z(I)
306   FORMAT (' ',2F10.3)
300   CONTINUE
      K=J+1
      X(K)=X(1)
      Z(K)=Z(1)
      SUM=0.
      DO 101 I=1,M
      DO 5 J=1,K
      Z(J)=Z(J)-PZ(I)
      X(J)=X(J)-PX(I)
5     CONTINUE
      DO 122 J=1,K
      IF(X(J).EQ.0..AND.(Z(J)).EQ.0.) GO TO 851
853   IF(X(J).EQ.0.) GO TO 499
      GO TO 852
851   TH=0.
      GO TO 498
852   IF (Z(J).EQ.0.) GO TO 861
      GO TO 854
861   IF (X(J).GT.0.) GO TO 863
      TH=-1*PI
      GO TO 498
863   TH=0.
      GO TO 498
854   TH=ATAN2(Z(J),X(J))
      GO TO 498
499   TH=PI*.5
      IF (Z(J).LT.0.) TH=-1*TH
498   IF (Z(J)) 501,502,502
501   TH=TH+PI*2
502   IF (J-1) 10,503,10
503   TH1=TH
      GO TO 122
10    TH2=TH
      L=J-1
      A=Z(J)-Z(L)
      B=X(J)-X(L)
      JJ=5
      IF (X(L)) 505,504,505
504   JJ=1
505   IF (X(J)) 507,506,507
506   JJ=2
507   IF (A) 509,508,509
508   JJ=3
```

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```
509   IF (B) 511,510,511
510   JJ=4
511   IF (TH1-TH2) 19,512,19
512   S=0.
      GO TO 102
19    IF (X(L)) 22,513,22
513   IF (Z(L)) 22,514,22
514   S=0.
      GO TO 102
22    IF (X(J)) 25,515,25
515   IF (Z(J)) 25,516,25
516   S=0.
      GO TO 102
25    GO TO (26,27,28,29,30),JJ
26    V6=TH2-.5*PI
      IF (ABS(V6)-PI) 518,518,517
517   V6=V6-SIGN (PIT2,V6)
518   S=(X(J)*X(J)*Z(L)/(A*A+X(J)*X(J)))*(V6+(A/X(J))*(ALOG(ABS(Z(L)))
     1-.5*ALOG(X(J)*X(J)+Z(J)*Z(J))))
      S1=S
      GO TO 102
27    V7=TH1-.5*PI
      IF(ABS(V7)-PI)519,519,520
520   V7=V7-SIGN (PIT2,V7)
519   S=(X(L)*X(L)*Z(J)/(A*A+X(L)*X(L)))*(V7-(A/X(L))*(ALOG(ABS(Z(J)))
     1-.5*ALOG(X(L)*X(L)+Z(L)*Z(L))))
      S2=S
      S=-S
      GO TO 102
28    V8=TH2-TH1
      IF(ABS(V8)-PI) 522,522,521
521   V8=V8-SIGN (PIT2,V8)
522   S=Z(L)*V8
      GO TO 102
29    V=SQRT((Z(J)*Z(J)+X(J)*X(J))/(Z(L)*Z(L)+X(L)*X(L)))
      V1=V
      S=X(L)*ALOG((X(L)/X(J))*V)
      S3=S
      GO TO 102
30    T=X(J)-(Z(J)*B/A)
      V=TH1-TH2
      U=B*A/(B*B+A*A)
      IF(ABS(V)-PI) 524,524,523
523   V=V-SIGN (PIT2,V)
524   W=(A/B)*.5*ALOG((Z(J)*Z(J)+X(J)*X(J))/(Z(L)*Z(L)+X(L)*X(L)))
      S=T*U*(V+W)
102   SUM=SUM+S
      TH1=TH2
122   CONTINUE
      DO 103 J=1,K
      Z(J)=Z(J)+PZ(I)
      X(J)=X(J)+PX(I)
103   CONTINUE
      DUM=SUM*13.346
      TIT(I)=TIT(I)+DUM
      SUM=SUM*RHO*13.346
      TOT(I)=TOT(I)+SUM
```

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```
      SUM=0.
101   CONTINUE
106   CONTINUE
      DO 1000 KT=2,M
      TIT(KT)=TIT(KT)-TIT(1)
1000  CONTINUE
      DO 633 I=1,M
      IF (PX(I).GT.GRADS) GO TO 621
      TOT(I)=TOT(I)+SUM-PX(I)*GRAD1
      GO TO 622
621   TOT(I)=TOT(I)+SUM-GRADS*GRAD1-GRAD2*(PX(I)-GRADS)
622   SUM=0.
633   CONTINUE
      TIT(1)=0.
      WRITE (5,315)
315   FORMAT('1',3X,'PX',8X,'PZ',9X,'TOT',10X,'TIT')
      WRITE (5,200)  (PX(I),PZ(I),TOT(I),TIT(I),I=1,M)
200   FORMAT (' ',F8.2,F12.4,F12.2,F12.4)
      GO TO 100
9999  CALL EXIT
      END
```

pt. 9/6

2-21-77 OAK GROVE GRAVITY LINE-FREE AIR MODEL 2

.996 =GRAD1 .746 =GRAD2 29.000 =GRADS

1.00 CROSS SECTION ID NUMBER

137 POINTS AT WHICH GRAVITY IS TO BE COMPUTED

12 BLOCKS IN MODEL

100.0000	-.0350
101.5000	-.0330
103.8300	-.0490
105.1700	-.0510
108.3300	-.0450
112.5500	-.0820
115.6400	-.1260
117.1600	-.1130
118.2000	-.0510
118.3300	-.0490
118.6100	-.0520
118.7400	-.0530
118.9900	-.0390
119.1600	-.0380
119.4100	-.0600
119.5200	-.0670
119.3100	-.0680
119.3400	-.0830
119.4400	-.0940
119.5500	-.1070
119.6600	-.1240
119.7900	-.1320
119.9600	-.1260
120.0800	-.1340
120.2100	-.1440
120.2900	-.1540
120.5300	-.1700
120.6500	-.1710
120.7600	-.1830
120.8600	-.1910
121.0100	-.2020
121.1300	-.2150
121.1900	-.2120
121.2700	-.2110
121.4300	-.2050
121.5100	-.2080
121.6300	-.2050
121.7200	-.2010
121.8100	-.1950
121.8900	-.1900
122.0200	-.1800
122.1000	-.1650
122.1900	-.1500
122.2400	-.1350
122.2600	-.1150
122.3300	-.1040
122.3800	-.0940
122.4400	-.0800

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122.6000	-.0610
122.6500	-.0540
122.6800	-.0540
122.7900	-.0460
122.9500	-.0410
122.9800	-.0380
123.0700	-.0370
123.1000	-.0350
123.1500	-.0340
123.1900	-.0270
123.2400	-.0370
123.3000	-.0380
123.3000	-.0350
123.4100	-.0230
123.5100	-.0200
123.5500	-.0120
123.6500	-.0030
123.7700	-.0020
123.8900	-.0120
123.9900	-.0170
124.0700	-.0170
124.1500	-.0230
124.1800	-.0240
124.3000	-.0240
124.3800	-.0190
124.4600	-.0210
124.5500	-.0200
124.6300	-.0220
124.7400	-.0240
124.8300	-.0300
124.9000	-.0340
125.0000	-.0370
125.1100	-.0400
125.2400	-.0460
125.3200	-.0550
125.3600	-.0600
125.4500	-.0650
125.5200	-.0710
125.6000	-.0800
125.6500	-.0880
125.7400	-.0980
125.8500	-.1000
125.9600	-.1030
126.0500	-.1070
126.1500	-.1060
126.1900	-.1060
126.2900	-.1050
126.3900	-.0990
126.4900	-.0960
126.5500	-.0910
126.6200	-.0860
126.1000	-.0820
126.7600	-.0790
126.8200	-.0690
126.9300	-.0580
127.0000	-.0450
127.0800	-.0460
127.0300	-.0430
127.1700	-.0320
127.2600	-.0270
127.3200	-.0260
127.3700	-.0290
127.4400	-.0360
127.4900	-.0340
127.5500	-.0400

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```
   127.6300    -.0470
   127.7000    -.0470
   127.8500    -.0440
   128.0200    -.0350
   128.1600    -.0320
   128.3000    -.0380
   128.4300    -.0340
   128.5900    -.0360
   128.7100    -.0400
   128.9100    -.0380
   129.0500    -.0420
   129.3000    -.0480
   130.8400    -.0880
   131.9500    -.1700
   132.7000    -.3200
   133.8000    -.2850
   135.0800    -.1510
   136.2000    -.0630
   138.5700    -.0740
   140.0400    -.0750
   142.5400    -.0760
   144.0000    -.0630
   145.5400    -.0250

   2.30 DENSITY
      9 CORNERS IN BLOCK
      1 BLOCK NUMBER


         X           Z        COORDINATES OF BLOCK CORNERS
       0.000       -.035
     100.000       -.035
     101.500       -.035
     103.830       -.049
     105.170       -.051
     108.330       -.045
     112.550       -.062
     100.000        .170
       0.000        .170

   2.60 DENSITY
    107 CORNERS IN BLOCK
      2 BLOCK NUMBER


         X           Z        COORDINATES OF BLOCK CORNERS
       0.000        .170
     100.000        .170
     112.550       -.082
     115.640       -.126
     117.160       -.113
     118.200       -.051
     118.380       -.049
     118.610       -.052
     118.740       -.053
     118.990       -.039
     119.180       -.038
     119.310       -.064
     119.340       -.083
     119.440       -.094
     119.550       -.107
     119.660       -.124
     119.780       -.132
     119.960       -.126
```

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120.210	-.144
120.290	-.154
120.530	-.170
120.650	-.171
120.760	-.183
120.860	-.191
121.010	-.202
121.130	-.215
121.190	-.212
121.270	-.211
121.430	-.205
121.510	-.208
121.630	-.205
121.720	-.201
121.810	-.195
121.890	-.190
122.020	-.180
122.100	-.165
122.190	-.150
122.240	-.135
122.260	-.115
122.330	-.104
122.380	-.094
122.440	-.080
122.540	-.066
122.600	-.061
122.660	-.054
122.680	-.054
122.790	-.046
122.930	-.041
122.980	-.038
123.070	-.037
123.100	-.035
123.150	-.034
123.190	-.027
123.240	-.037
123.300	-.038
123.410	-.023
123.510	-.020
123.580	-.012
123.650	-.003
123.770	-.002
123.890	-.012
123.990	-.017
124.070	-.017
124.150	-.023
124.180	-.029
124.300	-.024
124.380	-.019
124.460	-.021
124.550	-.020
124.630	-.022
124.740	-.024
124.830	-.030
124.900	-.034
125.000	-.037
125.110	-.040
125.240	-.046
125.320	-.055
125.360	-.060
125.460	-.065
125.520	-.071
125.600	-.080
125.650	-.088
125.740	-.096

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125.850	-.100
125.960	-.103
126.050	-.107
126.150	-.106
126.190	-.106
126.290	-.105
126.390	-.099
126.490	-.096
126.550	-.091
126.620	-.086
126.700	-.082
126.760	-.079
126.820	-.069
126.930	-.058
127.000	-.048
127.050	-.043
127.170	-.032
127.200	-.030
127.200	.040
118.500	.040
109.800	.230
100.000	.400
0.000	.400

2.40 DENSITY
10 CORNERS IN BLOCK
3 BLOCK NUMBER

COORDINATES OF BLOCK CORNERS

X	Z
0.000	.400
100.000	.400
109.300	.230
118.500	.040
122.600	.040
122.600	.075
118.500	.080
109.300	1.100
100.000	1.060
0.000	1.060

2.50 DENSITY
6 CORNERS IN BLOCK
4 BLOCK NUMBER

COORDINATES OF BLOCK CORNERS

X	Z
0.000	1.060
100.000	1.060
109.300	1.100
99.400	1.650
110.000	2.850
0.000	2.850

2.80 DENSITY
5 CORNERS IN BLOCK
7 BLOCK NUMBER

COORDINATES OF BLOCK CORNERS

X	Z
0.000	2.850
110.000	2.850
146.000	3.130

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245.000	5.130
245.000	5.000
0.000	5.000

2.78 DENSITY
18 CORNERS IN BLOCK
5 BLOCK NUMBER

X	Z
99.400	1.650
109.300	1.100
118.500	.000
118.500	1.000
127.200	1.405
127.200	1.400
130.000	1.400
134.500	1.400
137.000	.380
139.000	.350
144.000	.315
146.000	.200
149.950	0.000
153.000	-.060
246.000	-.060
246.000	3.130
146.000	3.130
110.000	2.650

COORDINATES OF BLOCK CORNERS

2.30 DENSITY
25 CORNERS IN BLOCK
9 BLOCK NUMBER

X	Z
128.800	-.039
128.910	-.038
129.050	-.042
129.300	-.038
130.840	-.088
131.950	-.170
132.300	-.285
132.700	-.320
133.100	-.320
133.500	-.285
133.800	-.203
135.080	-.131
136.200	-.083
138.570	-.074
140.040	-.075
142.540	-.076
144.000	-.063
145.540	-.025
148.800	0.000
146.000	.150
144.000	.250
139.000	.200
135.500	.220
130.300	.100
128.800	.100

COORDINATES OF BLOCK CORNERS

2.40 DENSITY
19 CORNERS IN BLOCK
10 BLOCK NUMBER

X	Z	COORDINATES OF BLOCK CORNERS
127.200	.190	
128.800	.130	
128.800	.100	
130.300	.105	
135.500	.220	
139.000	.200	
144.000	.250	
146.000	.150	
148.800	0.000	
149.950	0.000	
146.000	.200	
144.000	.315	
139.000	.350	
137.000	.380	
135.500	.400	
130.300	.330	
128.800	.330	
128.800	.400	
127.200	.400	

3.00 DENSITY
17 CORNERS IN BLOCK
18 BLOCK NUMBER

X	Z	COORDINATES OF BLOCK CORNERS
118.500	.080	
122.600	.075	
122.600	.150	
125.600	.150	
125.600	.075	
127.200	.075	
127.200	.400	
128.800	.400	
128.800	.330	
130.300	.330	
135.500	.400	
137.000	.380	
134.500	1.400	
130.000	1.400	
127.200	1.400	
127.200	1.485	
118.500	1.000	

2.20 DENSITY
19 CORNERS IN BLOCK
25 BLOCK NUMBER

X	Z	COORDINATES OF BLOCK CORNERS
127.200	-.030	
127.260	-.027	
127.320	-.026	
127.370	-.029	
127.440	-.030	
127.490	-.034	
127.550	-.040	
127.630	-.047	
127.700	-.047	
127.850	-.049	

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128.160	-.032
128.400	-.034
128.430	-.034
128.590	-.038
128.710	-.040
128.800	-.039
128.800	.190
127.200	.190

2.80 DENSITY
4 CORNERS IN BLOCK
30 BLOCK NUMBER

COORDINATES OF BLOCK CORNERS

X	Z
122.600	.040
125.600	.040
125.600	.150
122.600	.150

2.40 DENSITY
4 CORNERS IN BLOCK
31 BLOCK NUMBER

COORDINATES OF BLOCK CORNERS

X	Z
125.600	.040
127.200	.040
127.200	.075
125.600	.075

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PX	PZ	TOT	TIT
100.00	-.0350	467.70	0.0000
101.50	-.0330	468.59	-.0704
103.83	-.0490	472.27	.6009
105.17	-.0510	473.76	.6920
108.33	-.0450	476.22	.4615
112.55	-.0520	484.47	1.9861
115.64	-.1260	491.96	3.7751
117.16	-.1130	492.14	3.2232
118.20	-.0516	487.46	.6566
118.38	-.0490	488.16	.5789
118.61	-.0520	489.94	.7021
118.74	-.0530	490.64	.7313
118.99	-.0390	489.64	.0795
119.18	-.0380	489.48	-.1075
119.41	-.0600	489.05	-.3362
119.52	-.0670	489.29	-.2774
119.31	-.0680	492.94	1.1065
119.34	-.0830	494.69	1.7397
119.44	-.0940	496.32	2.2952
119.55	-.1070	497.90	2.8382
119.66	-.1240	499.90	3.5594
119.78	-.1320	500.96	3.8974
119.96	-.1260	500.47	3.6796
120.08	-.1340	501.39	3.9981
120.21	-.1440	502.50	4.3868
120.29	-.1540	503.61	4.7567
120.53	-.1700	505.43	5.4346
120.65	-.1710	505.55	5.4684
120.76	-.1830	506.82	5.9299
120.86	-.1910	507.68	6.2404
121.01	-.2020	508.83	6.6555
121.13	-.2150	510.13	7.1274
121.19	-.2120	509.88	7.0366
121.27	-.2110	509.78	6.9997
121.43	-.2050	509.13	6.7642
121.51	-.2080	509.39	6.8580
121.63	-.2050	508.99	6.7157
121.72	-.2010	508.48	6.5354
121.81	-.1950	507.76	6.2763
121.89	-.1900	507.13	6.0480
122.02	-.1800	505.78	5.5635
122.10	-.1650	504.04	4.9348
122.19	-.1500	502.13	4.2462
122.24	-.1350	500.07	3.5018
122.26	-.1150	497.86	2.6980
122.33	-.1040	497.21	2.4616
122.38	-.0940	496.13	2.0729
122.44	-.0800	494.62	1.5264
122.54	-.0660	493.22	1.0221
122.60	-.0610	492.77	.8527
122.66	-.0540	492.04	.5855
122.63	-.0540	492.09	.6017
122.79	-.0460	491.26	.3072
122.93	-.0410	490.76	.1425
122.98	-.0380	490.43	.0265
123.07	-.0370	490.35	.0048
123.10	-.0350	490.12	-.0759
123.15	-.0340	489.99	-.1169
123.19	-.0270	489.09	-.4403
123.24	-.0370	490.32	.0134
123.30	-.0390	490.43	.0570
123.30	-.0350	490.51	.0837

123.51	-.0290	4[illegible]8.55	-.6794
123.58	-.0120	487.38	-1.0251
123.65	-.0030	486.29	-1.4143
123.77	-.0020	486.19	-1.4357
123.89	-.0120	487.41	-.9811
123.99	-.0170	488.00	-.7559
124.07	-.0170	487.97	-.7548
124.15	-.0230	488.63	-.5064
124.18	-.0290	489.29	-.2633
124.30	-.0240	488.74	-.4474
124.36	-.0190	488.13	-.6596
124.46	-.0210	488.35	-.5704
124.55	-.0200	488.20	-.6155
124.63	-.0220	488.40	-.5323
124.74	-.0240	488.57	-.4554
124.83	-.0300	489.22	-.2045
124.90	-.0340	489.65	-.0364
125.00	-.0370	489.95	.0873
125.11	-.0400	490.23	.2042
125.24	-.0460	490.30	.4346
125.32	-.0550	491.77	.8004
125.36	-.0600	492.32	1.0083
125.46	-.0650	492.83	1.2116
125.52	-.0710	493.44	1.4495
125.60	-.0800	494.34	1.8062
125.65	-.0880	495.17	2.1273
125.74	-.0980	496.24	2.5404
125.85	-.1000	496.46	2.6471
125.96	-.1030	496.72	2.7730
126.05	-.1070	497.08	2.9305
126.15	-.1030	497.10	2.9702
126.19	-.1060	496.85	2.8948
126.29	-.1050	495.63	2.8501
126.39	-.0990	495.87	2.6123
126.49	-.0950	495.38	2.4134
126.55	-.0910	494.75	2.2806
126.62	-.0860	494.08	2.0780
126.10	-.0820	491.55	.9399
126.76	-.0790	492.95	1.7666
126.82	-.0690	491.70	1.3594
126.93	-.0580	490.13	.9096
127.00	-.0480	488.72	.4966
127.08	-.0480	487.59	.2954
127.08	-.0430	487.65	.2996
127.17	-.0320	485.36	-.1524
127.26	-.0270	482.85	-.3586
127.32	-.0260	482.13	-.3956
127.37	-.0290	482.10	-.2564
127.44	-.0300	481.84	-.2145
127.49	-.0340	482.04	-.0441
127.55	-.0400	482.43	.2108
127.63	-.0470	482.90	.5054
127.70	-.0470	482.76	.5138
127.85	-.0440	482.23	.3905
128.02	-.0350	481.18	.0140
128.16	-.0320	480.77	-.1117
128.30	-.0340	480.89	-.0275
128.43	-.0340	480.85	-.0309
128.59	-.0380	481.32	.1333
128.71	-.0400	481.78	.2137
128.91	-.0380	482.57	.1216
129.05	-.0420	483.19	.2635
129.30	-.0380	482.64	.[illegible]
130.84	-.0880	485.84	2.0271
131.95	-.1700	490.82	4.5257

pt 4/

133.80	-.2050	495.94	6.5007
135.08	-.1310	479.81	2.7686
136.20	-.0830	474.54	1.8503
138.57	-.0740	469.39	1.6050
140.04	-.0750	467.95	1.0529
142.54	-.0760	465.51	1.6816
144.00	-.0650	463.05	1.1353
145.54	-.0250	459.44	-.4306

519445

PT.4/1

```
===> $EOJ

******JOB EXITED ON 27 MAY 77 18:11:27    ******

******CPU TIME=        0MINS   26.32SECS  ******

******CONNECT TIME=       1MINS   12SECS  ******
```